KIEFER CREEK WATERSHED RESTORATION PLAN

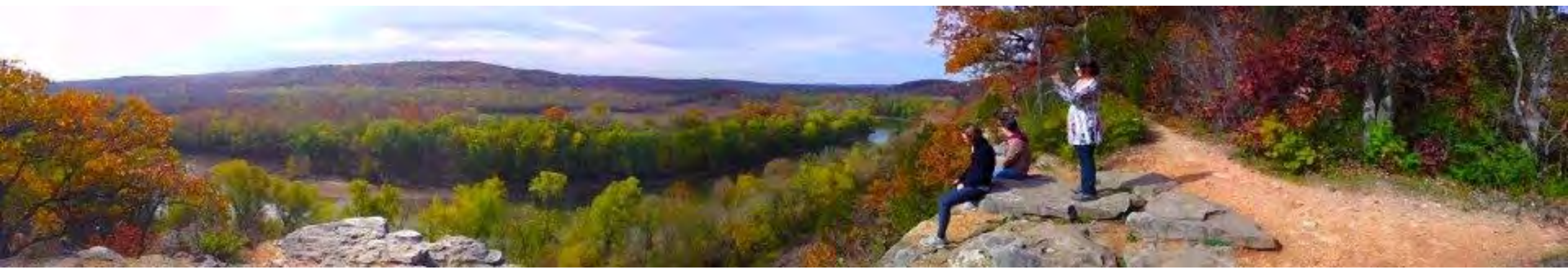
DRAFT DEVELOPMENT COPY

10/2014

Missouri Department of Natural Resources

This watershed plan and other efforts related to the Kiefer Creek Restoration Project are partially funded by the Environmental Protection Agency Region 7 through the Missouri Department of Natural Resources, under Section 319 of the Clean Water Act. MoDNR Subgrant G13-NPS-01

MCE
Missouri Coalition for the Environment
EFFECTIVE CITIZEN ACTION SINCE 1969



The Kiefer Creek Watershed Restoration Project has been supported by numerous individuals and entities, who have provided generous support through grants, volunteerism, and participation in our watershed planning process. Many have found reason to rally around Kiefer Creek, one of the last best creeks in our region. We appreciate the support we have received in our efforts thus far and hope that our partners will continue to work with the Kiefer Creek Watershed Coalition to implement the priorities of the watershed plan.

GRANT FUNDING
Environmental Protection Agency: Missouri Department of Natural Resources
319 Non-Point Source Pollution Reduction Program
National Fish and Wildlife Foundation 5-Star Restoration Grant Program
Trio Foundation
Crawford Taylor Foundation
Gaylord Foundation
Commerce Bancshares
Patagonia

PARTNER AGENCIES & INSTITUTIONS
Missouri Department of Natural Resources Division of State Parks,
Missouri Department of Natural Resources Non-Point Source Pollution Division.
and
Missouri Department of Natural Resources Water Quality Division
Missouri Department of Conservation
Missouri Stream Teams Program
Metropolitan St. Louis Sewer District
East-West Gateway Council of Governments
Webster University Department of Ecology
Washington University Department of Earth & Planetary Sciences
Rockwood School District: Center for Creative Learning

CONSERVATION & ENVIRONMENTAL ORGANIZATIONS & COMMUNITY GROUPS
The Wildlife Rescue Center
St. Louis Audubon
The Open Space Council
The Nature Conservancy
Missouri Master Naturalists Great Rivers Chapter
Missouri Master Naturalists Confluence Chapter

We would also like to give a special thanks to the following people for their excellent support of our efforts: Catherine Fireman, Randy Becknell, Roland Biehl, Angie Weber, Erin Shank, Mark Grueber, Alan Hopfl, John Johnson, Jane Davis, Diane Muenks, Amanda Torv, John Hoke, Greg Anderson, Dr. Bob Criss, Jeff Depew, Nancy McCLintock, Cori Westcott, Stephanie Mafla-Mills, Bob Coffing. Garrett from Castlewood, Mike Brady, Karen Meyer, Blake LaRue, Kim Rutledge, Eric Wilkenson, Ellie Lorenzi, Jocelyn Lee, Nicolle Taniuchi, Lynda Morrison, Helen Pierson, Hannah Behar, Katie and Jacob Siech.

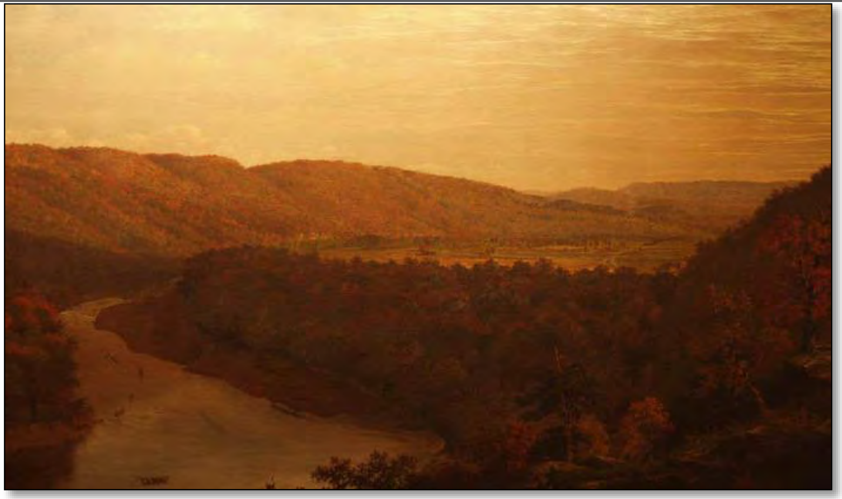
Table of Contents

Kiefer Creek flows through the heart of Castlewood State Park, at the center of a natural outdoor recreation area cherished by the St. Louis community for over 100 years. Kiefer Creek is a tributary to the Meramec River, one of the most biologically diverse, free-flowing, and healthy rivers in any urban area in the United States. In the 1970's, after a hard fought battle with the federal government, Missourians staunchly rejected proposals to dam this natural wonder. Kiefer Creek is one of the last and most threatened tributaries to the Lower Meramec, that still retains a strong forest system and perennial spring flows. Clear waters flow gently through the park, forming pools that are perfect for cooling off on hot summer days, making the creek a popular swimming destination.

The creek's natural beauty is an asset to the community. The people in the watershed are clearly proud of their creek – many of the neighborhoods, roads and businesses in the area are named after Kiefer Creek. Unlike their neighbors in nearby watersheds, the people in the Kiefer Creek community can boast about their creek's natural flowing water, as well as the beauty of their forested and hilly watershed. When travelling through the Kiefer Creek watershed, you get the impression you're no longer in the suburban sprawl of St. Louis County - the trees, steeply sloped hillsides and clear flowing water transport you back in time. Even in the parts of the watershed with significant suburban development, the residents have stunning views of the beautiful landscape.

Unfortunately, Kiefer Creek exhibits high levels of bacteria after rainfall. In testing by the USGS between 1996 and 2004, bacteria levels exceeded safe levels for recreation after increased flows from rainfall in the watershed. In 2010, Kiefer Creek was placed on the 303(d) List of Impaired Waters for exceeding the safe level of bacteria for recreational use. Then in 2012 an additional impairment of aquatic life use was assigned due to high chloride levels. Both of the impairments on Kiefer Creek are not uncommon in the metro area, however in Kiefer Creek the bacteria can be exceptionally high and the potential for public use is also extremely probable given the typical use of the creek in Castlewood. The chloride issue is one that can be brought under control, especially if there isn't a great expansion of pavement.

The goal of this project is to design and implement a plan to clean up Kiefer Creek. Such a valuable resource can be restored and preserved through strategic improvements in the watershed. We invite you to join us as we embark on the path toward a watershed that is safe for people, pets, and wildlife to enjoy on any day of the year. Participation in this project is voluntary, but we believe that the improvements will provide myriad benefits for watershed property owners and the creek's water quality in one of the last, lovely, spring-fed creeks in St. Louis County.



Joseph Rusling Meeker (1827 – 1887)
View of the Meramec River near Glencoe, ca.1872, oil on canvas
Collection of the St. Louis Mercantile Library at the University of Missouri - St. Louis

Pre-Development

Prior to the 1770’s when European settlers began occupying the area, the Kiefer Creek Watershed was likely home to people of the Osage and Illinois Tribes. Before development of the area, the Kiefer Creek watershed was covered primarily by forests, with patchy glades among the rocky cliffs carved by the path of the Meramec. Beaver-built dams would have produced diverse natural wetlands along the stream channel. Many species would have flourished in these spring fed wetlands, including an amazing diversity of amphibians, shellfish, mussels, turtles, fish, crawfish and other macro-invertebrates. These would be the foundation of a predatory branch of the food chain that would top out with mountain lions and bears, The bison, deer, elk and other herbivores in the area would thrive on a diet of diverse native trees, shrubs, grasses, wildflowers, and aquatic plants. The creek was fed by numerous perennial and intermittent springs, and the stream bed was frequently punctuated by deep holes that likely served as a prime reproductive area for aquatic macroinvertebrates, fish and shellfish. Without the massive pulses of stormwater from impervious surface runoff, the stream channel would be much narrower than it is today, likely winding sinuously through forested wetlands..

Early Popularity

In the second half of the 1800's the Lower Meramec became a popular destination for fishing trips, with visitors coming all the way from St. Louis’s urban center. Gravel mining operations taking place around the same time resulted in deposits of sandy beaches along the banks of the Meramec. These beaches became popular destinations for weekend trips around the turn of the 20th century. The Castlewood station of the Missouri Pacific Railroad provided easy access to the Kiefer Creek area for city dwellers, and a resort community developed in the early 1900s. Between 1900 and 1930 resorts, river outfitters, restaurants, hotels and even speakeasies we built to cater to the visiting crowds. The 'ruins' of the Castlewood Resort can still be seen on the grounds of what is now the Wildlife Rescue Center. The Lincoln Lodge stood in what is now Lincoln Field in Castlewood State Park, and the Lone Wolf Saloon has been converted into a home.

Decades of Decline

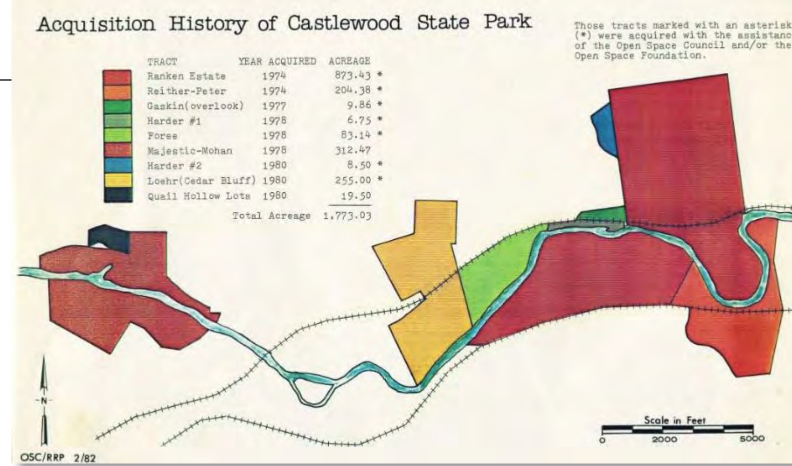
Somewhere between the Great Depression and the end of World War II, the Castlewood area began to decline in popularity. As more people had access to cars, and roads and highways reached out across the country, people stopped flooding the area. The watershed remained for the most part outside of the suburban growth of St. Louis until the 1970's, with the exception of Manchester Road along northern edge of the watershed. In this span of time the area was subject to many of the problems common to the Lower Meramec such as dumping, septic issues and the decline of abandoned structures.

Toxic Legacy

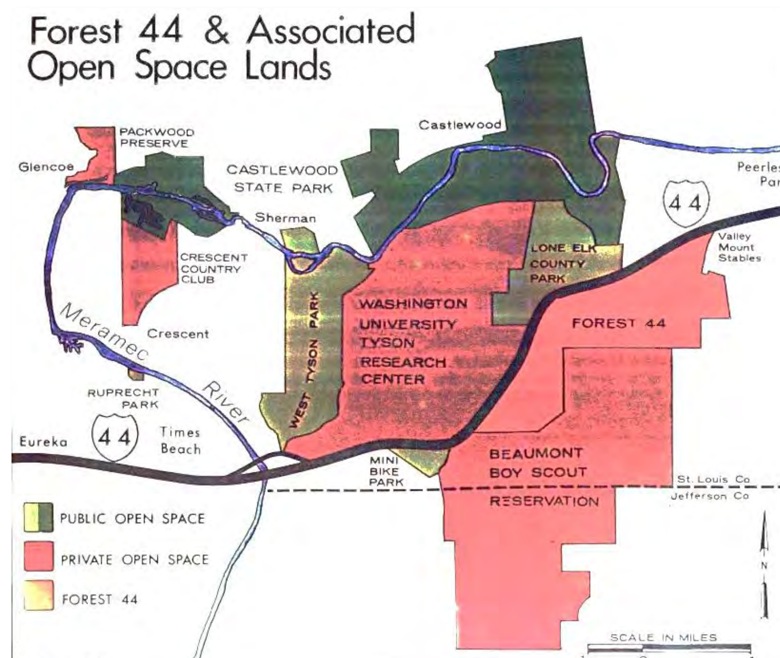
Times Beach, a small town about 20 miles south of St. Louis along the Meramec, is the site of a well known Superfund Cleanup site. The town was evacuated in the early 1980's due to dioxins found in waste oil sprayed on dirt and gravel roads and parking lots to control dust. The Superfund Cleanup that followed necessitated the construction of an incinerator to burn the toxic waste. The areas within the watershed that were included in the Superfund site have not been redeveloped for the most part, however a few new homes along roads that were cleaned up have been built and existing homes are generally inhabited. There is also a large un-utilized lot, currently owned by MSD, along Sontags Road that was the location where the contaminated soils were stored prior to the completion of a disposal incinerator.

Resource Conservation

With great foresight the State of Missouri made major investments in conservation and, with the help of the Open Space Council, acquired the lands that comprise Castlewood State Park. The initial investments in the park began in 1974, with subsequent acquisitions in 1977, 1978, and 1980.This new park along the Meramec fit into a larger set of conservation investments in the surrounding area at Forest 44, Tyson Research Center and Beaumont Boy Scout Ranch. Together these protected areas have preserved great expanses of forest and floodplain



along the western Lower Meramec River including the entire length of the main branch of Kiefer Creek. Adding on to these areas, the City of Ellisville dedicated a portion of the upper watershed as Bluebird Park, and the Missouri Department of Conservation received the Klamberg Woods Conservation Area through a conservation easement donated by the Klamberg Family adjacent to bluebird park.

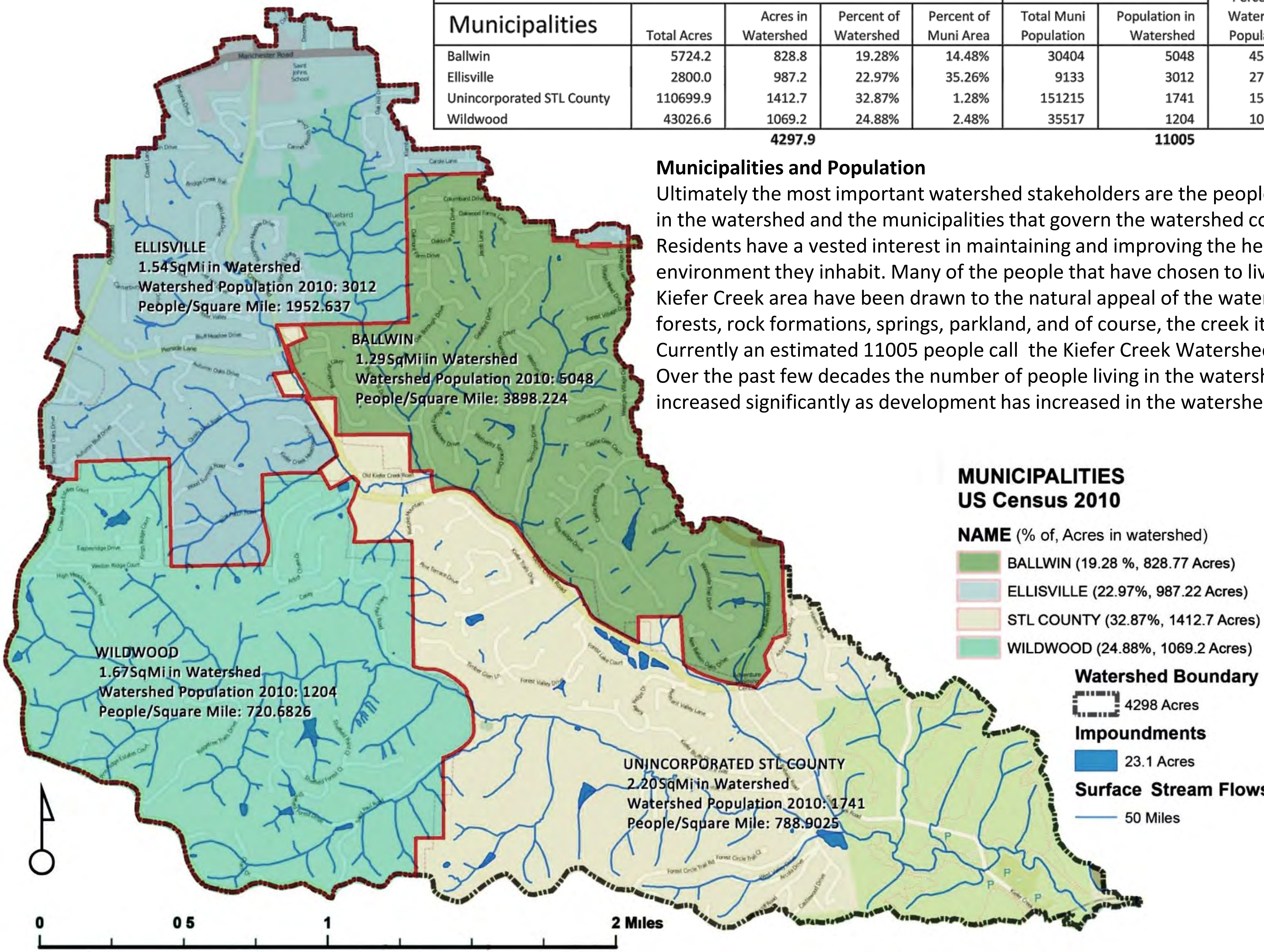


The Meramec River, The Open Space Council And YOU!
February 1982, Roger Pryor

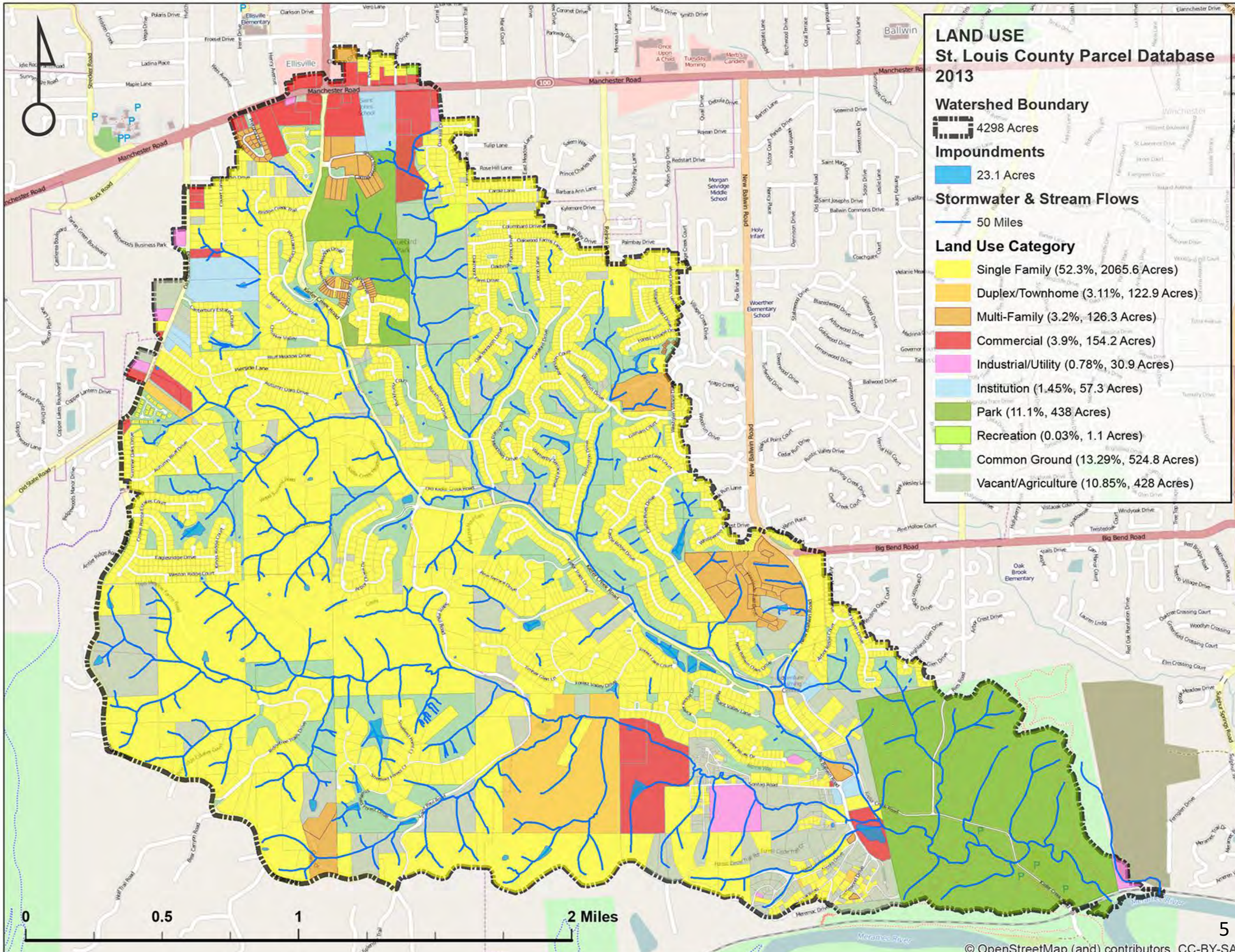
Municipalities	Total Acres	Acres in Watershed	Percent of Watershed	Percent of Muni Area	2010 CENSUS Total Muni Population	2010 CENSUS Population in Watershed	Percent of Watershed Population	Percent of Municipal Population
Ballwin	5724.2	828.8	19.28%	14.48%	30404	5048	45.87%	16.60%
Ellisville	2800.0	987.2	22.97%	35.26%	9133	3012	27.37%	32.98%
Unincorporated STL County	110699.9	1412.7	32.87%	1.28%	151215	1741	15.82%	1.15%
Wildwood	43026.6	1069.2	24.88%	2.48%	35517	1204	10.94%	3.39%
		4297.9				**11005**		

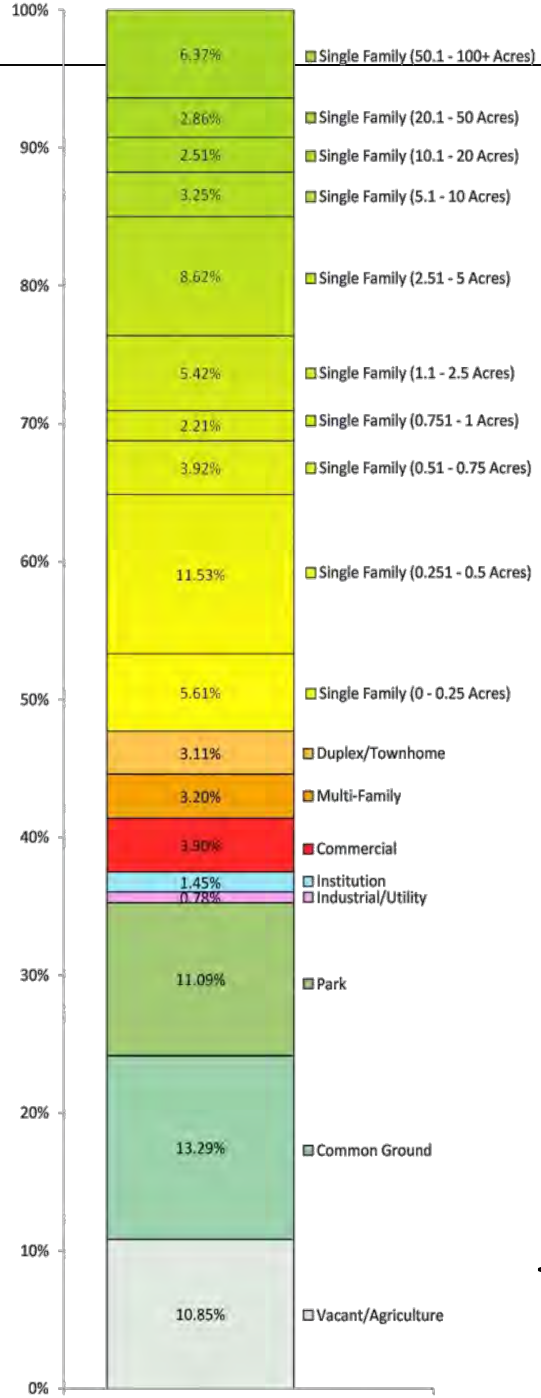
Municipalities and Population

Ultimately the most important watershed stakeholders are the people that live in the watershed and the municipalities that govern the watershed community. Residents have a vested interest in maintaining and improving the health of the environment they inhabit. Many of the people that have chosen to live in the Kiefer Creek area have been drawn to the natural appeal of the watershed's forests, rock formations, springs, parkland, and of course, the creek itself. Currently an estimated 11005 people call the Kiefer Creek Watershed home. Over the past few decades the number of people living in the watershed has increased significantly as development has increased in the watershed.



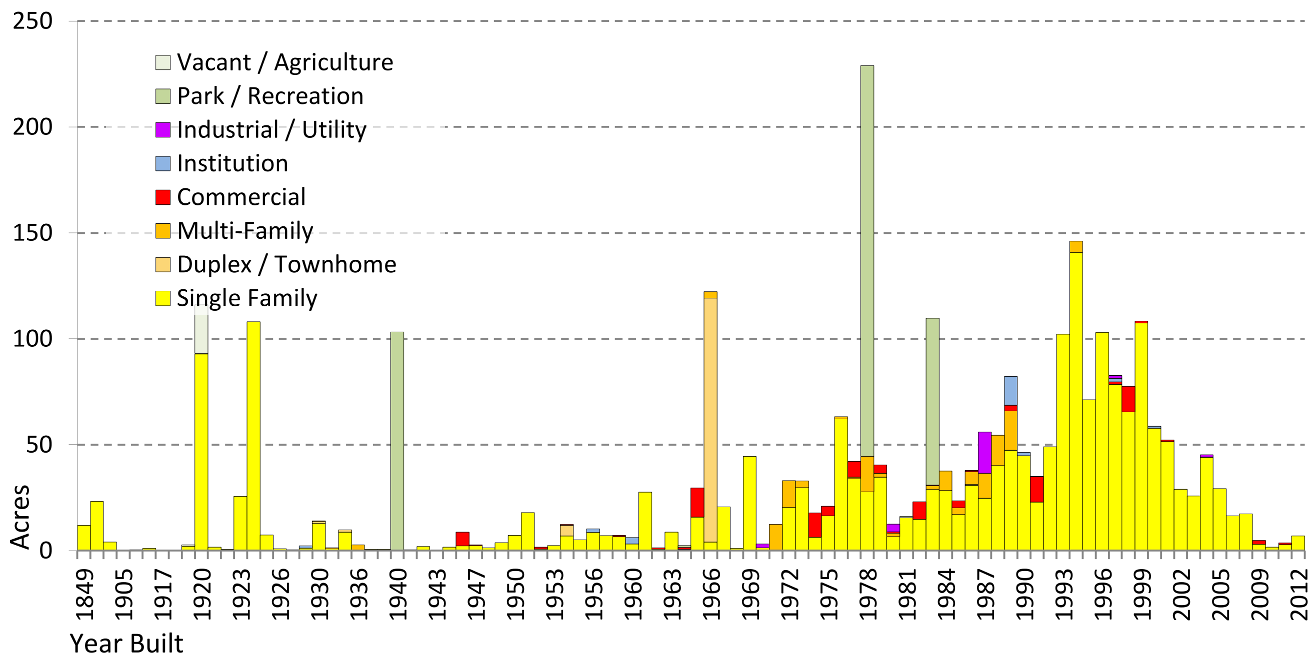
Watershed Community: Current Land Use





Land Use Analysis

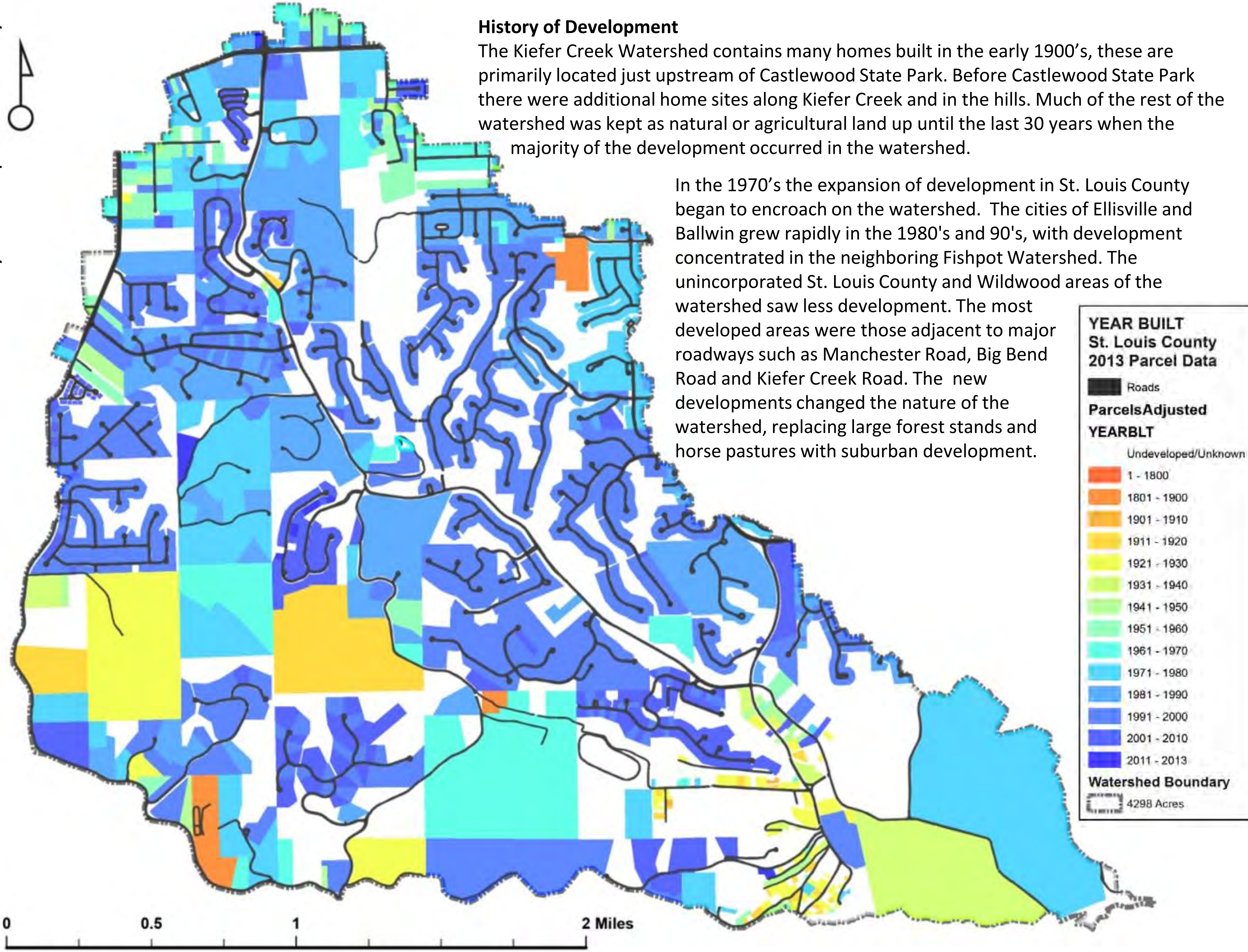
Land use is a key factor in understanding the composition of a watershed. In the Kiefer Creek Watershed we used this data to understand the breakdown of relative lot sizes and study the rate of growth of each use in the watershed over time. By comparing relative lot sizes we can separate large land owners from higher density typical suburban development, then promote appropriate strategies for the range of land ownership in the watershed. In the Kiefer Creek Watershed we found that nearly 30% of the watershed is held in residential parcels greater than one acre in size, while another 35% of the watershed is either parkland, common ground or undeveloped. The ecology and hydrology of Kiefer Creek likely depend heavily on this land remaining largely green space, and could be improved by implementing restoration and enhancement activities on these lands. The higher density suburban residential and commercial development primarily in the north and eastern reaches of the watershed represents an important group of stakeholders to engage on stormwater related issues such as rock salt and pet waste. We can also use this data to tell us when and where the greatest changes occurred in the watershed , which has revealed a dramatic rate of change in land use beginning in the early 1970s increasing to a peak in the mid 90's then from there declining towards the real estate collapse of 2008. This pattern over time explains , to some degree, why we see that many area s in and along the Kiefer Creek channel that were erosive have stabilized and are seeing a resurgence of hydrophilic vegetation.



History of Development

The Kiefer Creek Watershed contains many homes built in the early 1900's, these are primarily located just upstream of Castlewood State Park. Before Castlewood State Park there were additional home sites along Kiefer Creek and in the hills. Much of the rest of the watershed was kept as natural or agricultural land up until the last 30 years when the majority of the development occurred in the watershed.

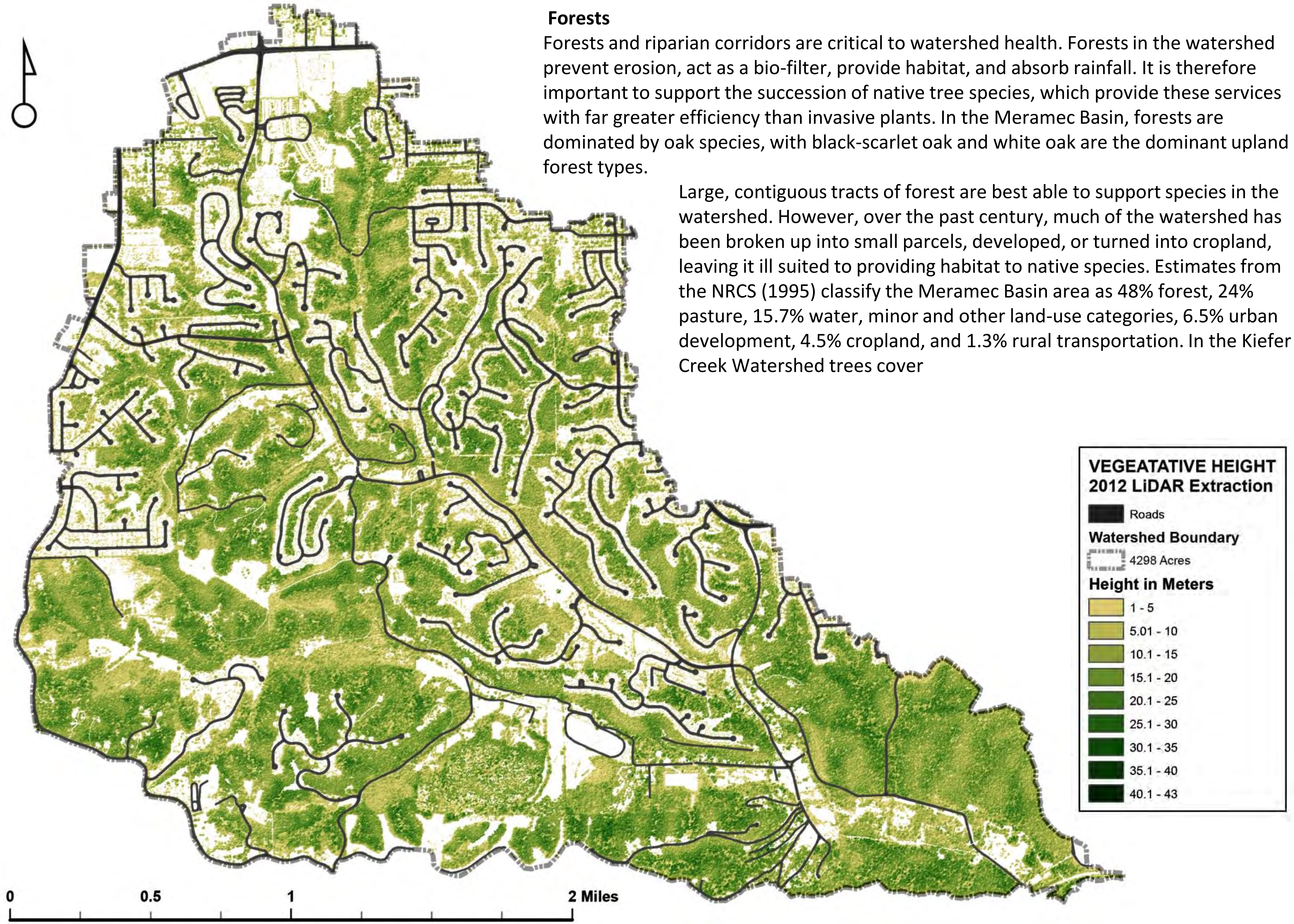
In the 1970's the expansion of development in St. Louis County began to encroach on the watershed. The cities of Ellisville and Ballwin grew rapidly in the 1980's and 90's, with development concentrated in the neighboring Fishpot Watershed. The unincorporated St. Louis County and Wildwood areas of the watershed saw less development. The most developed areas were those adjacent to major roadways such as Manchester Road, Big Bend Road and Kiefer Creek Road. The new developments changed the nature of the watershed, replacing large forest stands and horse pastures with suburban development.



Forests

Forests and riparian corridors are critical to watershed health. Forests in the watershed prevent erosion, act as a bio-filter, provide habitat, and absorb rainfall. It is therefore important to support the succession of native tree species, which provide these services with far greater efficiency than invasive plants. In the Meramec Basin, forests are dominated by oak species, with black-scarlet oak and white oak are the dominant upland forest types.

Large, contiguous tracts of forest are best able to support species in the watershed. However, over the past century, much of the watershed has been broken up into small parcels, developed, or turned into cropland, leaving it ill suited to providing habitat to native species. Estimates from the NRCS (1995) classify the Meramec Basin area as 48% forest, 24% pasture, 15.7% water, minor and other land-use categories, 6.5% urban development, 4.5% cropland, and 1.3% rural transportation. In the Kiefer Creek Watershed trees cover



Karst in Kiefer Creek

The bedrock in the Kiefer Creek area is mainly limestone, a rock type that is easily eroded by a high water table such as that in the Kiefer Creek area. As a result, Kiefer Creek has developed a Karst Topography, meaning that the limestone bedrock has been cut through by water and low concentrations of carbonic acid, becoming porous over time. A low elevation and high water table leads to the formation of spring fed streams like Kiefer Creek. 'Losing streams', streams in which some of the flow is lost as it is distributed through the porous bedrock to the groundwater, are a prevalent feature of Karst topography.

Kiefer Creek is fed by at least six significant springs throughout the watershed, and major portions of the creek may be categorized as losing streams. These two conditions mean that the water quality of Kiefer Creek is dependent on the quality of the groundwater in addition to the quality of the runoff and drainage that reaches the stream bed. This makes Kiefer Creek highly susceptible to bacteria leaked from faulty septic systems in the area. In addition, groundwater does not follow the topographical boundaries that delineate watersheds, and it is likely that the spring water feeding Kiefer Creek originated from an area much wider than the watershed, carrying with it the accumulated contamination. According to tests done for the East West Gateway's1978 St. Louis Water Pollution Control Study on areas tributary to the Lower Meramec, the groundwater in the Kiefer Creek area flows in a northeast direction, suggesting that some of the water entering Kiefer Creek through the various springs likely contains contamination from the nearby Jefferson County among others. This connectivity provides a good incentive to make efforts to built partnerships in the area and set stewardship precedents for other watersheds.

Hydrology & Habitat

Public & Private Partnerships for Watershed Restoration

Watersheds are complex systems that must be considered in many dimensions simultaneously to identify solutions to water quality and ecosystem degradation. Pollution comes from throughout a watershed, from point source pollution outfalls and from non-point sources but water quality can also be influenced greatly by the watershed's ability to absorb rainfall. Impervious surfaces like roads, parking lots, and buildings cause an increase in the volume and speed of stormwater runoff as well as a reduction in rainfall absorption which replenishes groundwater and the springs the feed many of our streams. In fact, many of the landscape decisions made on public and private ground are at the crux of watershed health. A typical compacted sod lawn absorbs a relatively small amount of water as compared to a native prairie or forest. A properly restored wetland will provide far superior water quality, magnitudes greater ecosystem services, and excellent natural flood mitigation benefits when compared to the typical stormwater detention pond.

To truly restore a watershed we must not just look to the traditional point and non-point sources and begin to harvest the low hanging fruit of simple native landscape restoration. We can begin to make significant strides toward improving water quality by choosing native trees, shrubs, grasses, and wildflowers. By making the right selections, anyone can help restore the watershed's ability to replenish groundwater, providing a constant flow of clean water to offset the impacts of point and non-point source pollution.

Water Quality Assessment: Bacteria

- Water Quality Standards
- Designated Use Impairment
- Water Quality Monitoring Data and Analysis
- Bacteria Source Assessment
- Pollution Reduction Strategies & BMPs

The high bacteria levels in Kiefer Creek could come from a variety of sources in the watershed, the most likely being faulty septic systems contaminating the groundwater and pet and wildlife waste washed into the creek. E. coli is a common bacterium found in the digestive tract of all warm-blooded animals. E. coli is often used as an indicator that waters are polluted with animal or human waste and potentially harmful to human health. Although there have been no previous studies specific to Kiefer Creek, it has been included in Meramec River Watershed plans since they began to be written, as well as plans for neighboring Meramec tributaries.

WATER QUALITY DATA

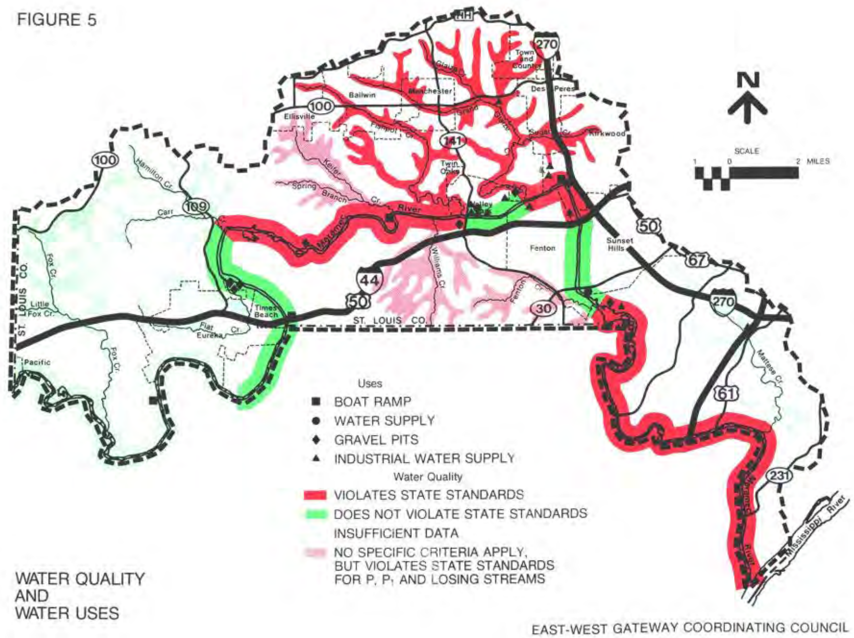
Table A-2 (Sheet 4 of 12)

Location: Crossing of Kiefer Creek and Kiefer Creek Road (Map Location "M-5")

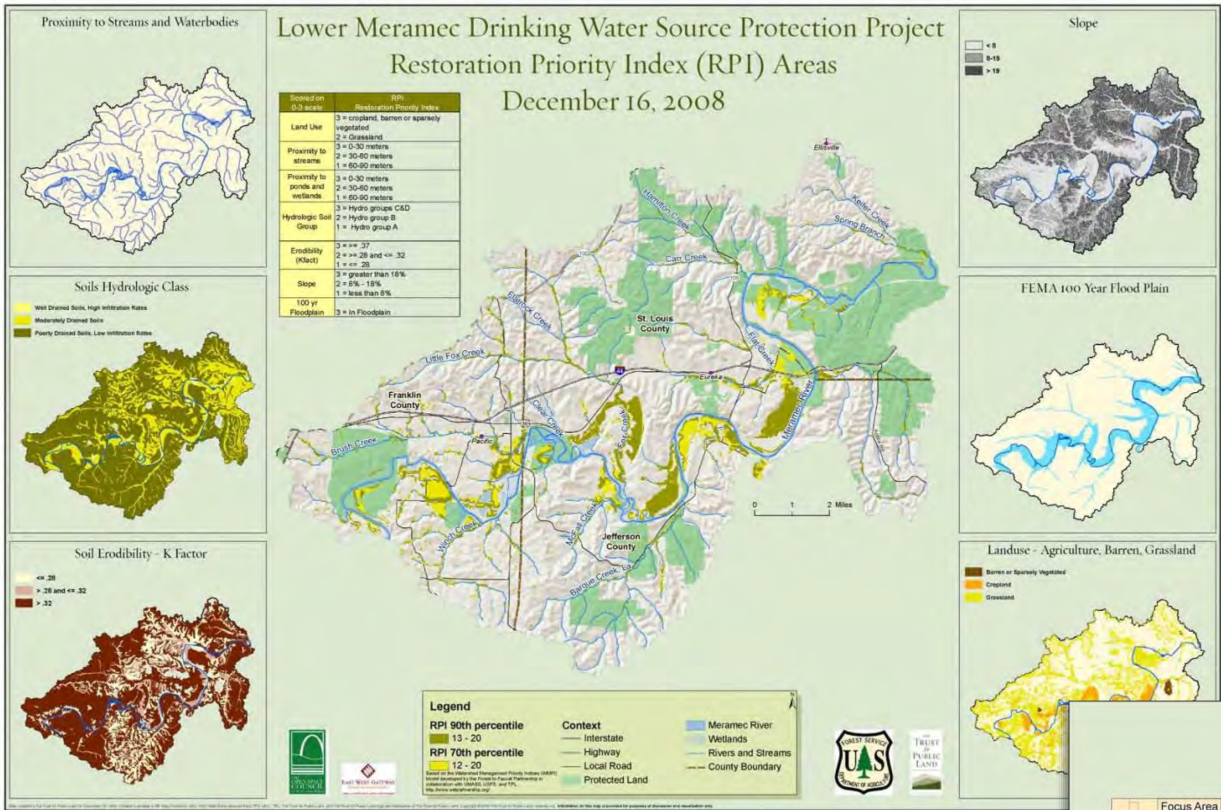
Date	Coliform Total Per 100 ml. MPN	Coliform Fecal Per 100 ml MPN	Streptococcus Fecal Per 100 ml MPN
8/2/71	1300	300	220
8/3/71	1300	230	1300
8/10/71	2300	170	20
8/11/71			
8/18/71	3300	330	330
8/19/71	3100	330	110
8/26/71	1300	78	700
8/27/71	790	78	230

St. Louis County Water Pollution Control Study Phase I – Areas tributary to the Meramec River MSD-September 1972

Historical data shows Kiefer having a steadily elevated level of Coliform bacteria, although not nearly as high as has been recorded by the USGS, MSD and MDNR in recent years.. In September 1972 the East West Gateway Council published the St. Louis County Water Pollution Control Study - Phase I - Areas Tributary to the Meramec River. In this study, EWG looked specifically at the potential to expand sewer services to tributary areas of the Lower Meramec River, with specific emphasis on Fishpot and Grand Glaize Creek, but also including the Kiefer Creek Watershed. At the time that this study was conducted the problems with wastewater that persist in Kiefer Creek, were prevalent in Fishpot and Grand Glaize Creek as well. As a regional planning agency, EWG saw that the population would inevitably expand into these areas and the existing wastewater infrastructure, or lack thereof, would be inadequate to handle this influx. This study included testing of three locations in the Kiefer Creek Watershed for a variety of parameters. The data indicates high bacteria levels in Kiefer Creek, showing that Kiefer Creek has had a bacteria problem for a long time, although the scale may have fluctuated over time. Current data shows that Kiefer can have very low levels of bacteria during low water and very high levels during high water.

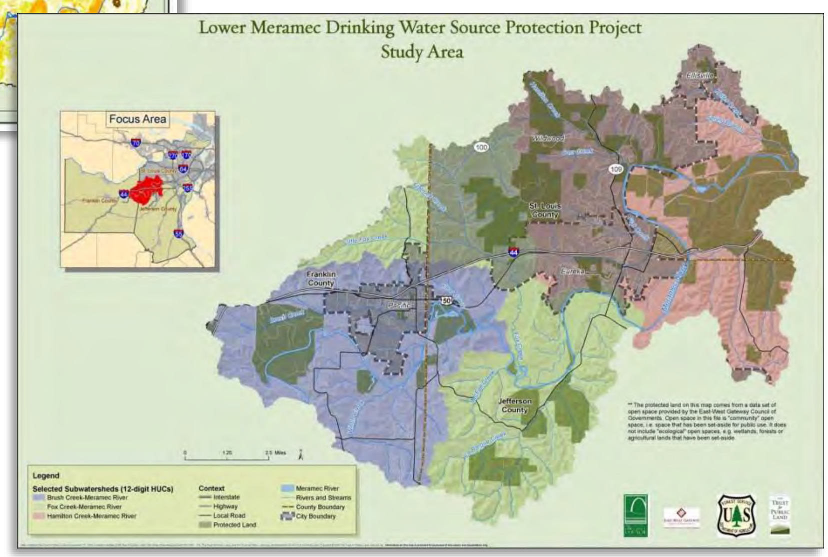


1980 Section 208 Water Pollution Control Plan for the St. Louis Region was created by the East West Gateway and although it covered the greater St. Louis region, it focused in on the Meramec River Basin and the Lower Meramec Watershed as an area for a long term focus on improving water quality. The 208 Plan demonstrated that in-stream water quality could not be met with point source controls alone, emphasizing the need for watershed planning to address nonpoint sources in the area. Because of this, the 208 plan identifies both sewage facility construction and stormwater management as areas to focus on.



The report prepared for the Exchange emphasizes the importance of education for residents and municipal officials on BMPs for watershed health. The 2009 plan outlines the following five goals as high priority:

1. Develop strategies to protect a vitally important source of drinking water for 200,000 St. Louis county residents.
2. Improve and protect habitat and recreational areas in streams and restore degraded tributaries.
3. Develop strategies to protect healthy, sensitive streams that are at risk of being degraded by human actions.
4. Develop long range plans for public education.
5. Achieve and maintain compliance with water quality standards.

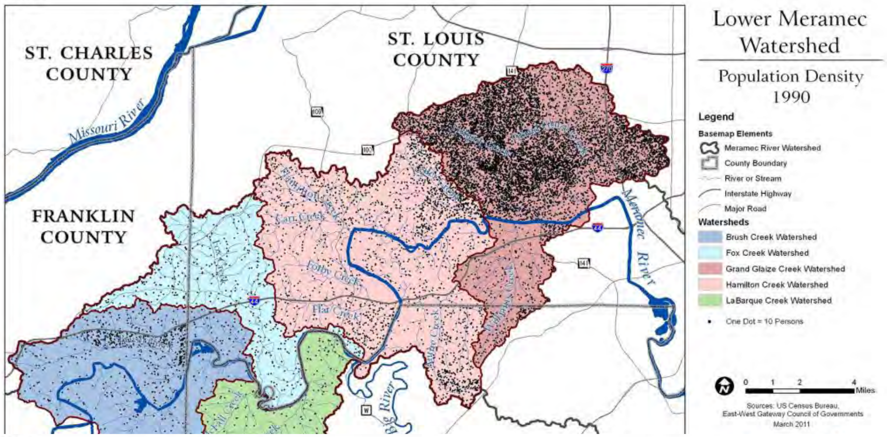


2009 Source Water Protection Plan for the Meramec River Exchange

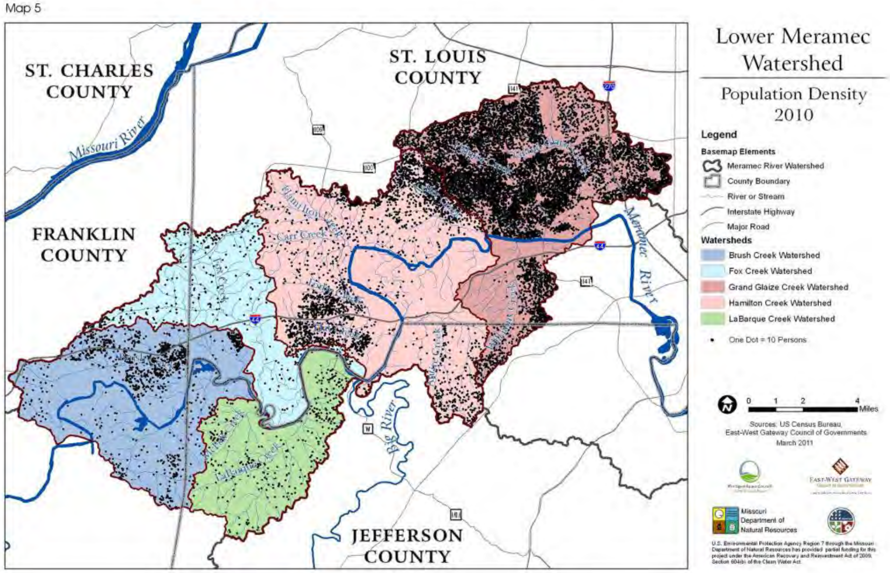
The 2009 Exchange was funded by a grant from the US Forest Service and was undertaken by the St. Louis Regional Open Space Council and a coalition of more than thirty agencies and organizations. In preparation for the exchange, a report summarizing watershed conditions in three HUC-12 sub-basins of the Lower Meramec was prepared. This report includes a set of maps depicting the watershed attributes and conditions, as well as contextual and historical information relevant to the current conditions of the Meramec as a drinking water source. This report identified a broad range of point and non-point source pollutants and historical degradation of the Lower Meramec Watershed. The 2012 Lower Meramec Watershed Plan specifically recommends the development of sub-watershed plans, listing Kiefer Creek as a high priority.

2012 Lower Meramec Watershed Plan is the most recent planning effort on the Meramec River is the 2012 Lower Meramec Watershed Plan. The 2012 plan is a Nine Element Watershed Plan that builds on The 208 Plan. It includes The Kiefer Creek Watershed (7 sq. miles) in the planning area, as well as many other tributaries to the Lower Meramec. In total this plan covers 182.2 square miles and looked at a broad range of issues from many different watersheds.

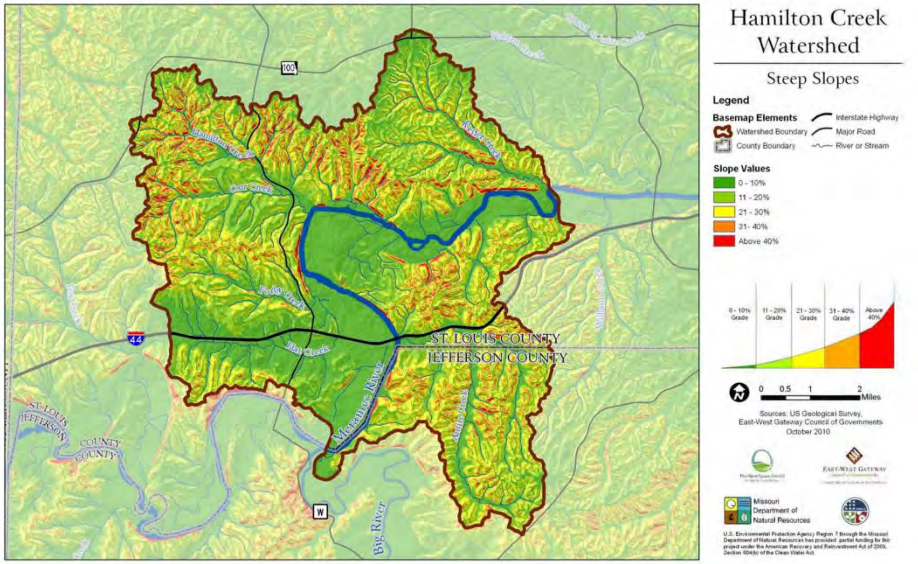
Map 3



Map 5



Map 33



The 2012 Lower Meramec Watershed Plan continues to address, and expands upon the goals of the 2009 plan in the following areas:

1. Timeline : The 2012 plan proposes a long term framework for impaired sub-watersheds, as well as short and mid term actions for local residents as well as local government public agencies.
2. Models, Monitoring and Load Reductions : In writing the plan, the East West Gateway analyzed twenty-six existing watershed models to create a comprehensive model that spans the urban and suburban settings of the Lower Meramec Watershed.
3. City, County and State Owned Public Lands : A key recommendation of the plan is to focus on public lands within the watershed. Communities and agencies can quickly move to implement BMPs in parks and other public lands
4. Sub-Watershed Planning : The plan emphasizes the importance of sub-watershed plans, especially for the three impaired sub-watersheds, Kiefer Creek, Fishpot Creek and Grand Glaize Creek.
5. Public Awareness and Education : The East West Gateway hosted public meetings to raise awareness about water quality issues in the area. The EWG also plans to develop informational brochures, and to provide a framework to its partners in the Meramec River Tributary Alliance (MRTA) for future action.

Water Quality Standards & Impairment

Water quality standards are the biological and chemical criteria required to support a given designated use. Waters protected under the Clean Water Act, known as Waters of the United States , are assigned designated uses. Designated uses in Missouri include supporting aquatic life, recreational use, irrigation, livestock watering, wildlife, industrial processes, and source drinking water. Each of these uses is accompanied by a set of science based numeric criteria that are used to determine if a Water of the United States is capable of supporting the uses assigned to it. Numeric standards have been developed to determine which waters of the US are impaired based on monitoring data collected primarily by regulatory and scientific agencies as well as regulated entities. The Missouri numeric water quality standards for bacteria concentrations to protect recreational uses are as follows:

Pollutant (/100 mL)	WBC-A	WBC-B	SCR
E. coli Bacteria**	126	206	1134

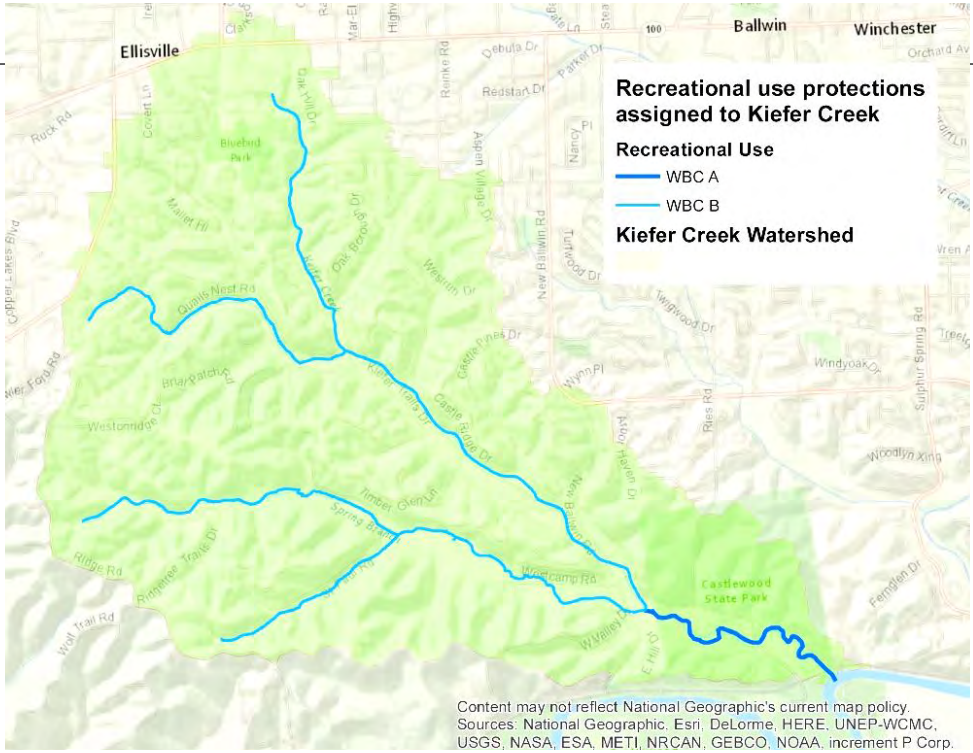
**Geometric mean during the recreational season in waters designated for recreation or at any time in losing streams. The recreational season is from April 1 to October 31.

WBC – Whole Body Contact Recreation

SCR – Secondary Contact Recreation

Under the Clean Water Act, an impaired waterway is one that is “too polluted or otherwise degraded to meet the water quality standards set by states, territories or authorized tribes.” Under section 303(d) of the Clean Water Act, states, territories, and authorized tribes are required to develop lists of impaired waters. These are waters that are too polluted or otherwise degraded to meet the water quality standards set by states, territories, or authorized tribes. The law requires that these jurisdictions establish priority rankings for waters on the lists and develop TMDLs for these waters. A Total Maximum Daily Load, or TMDL, is a calculation of the maximum amount of a pollutant that a water body can receive and still safely meet water quality standards.

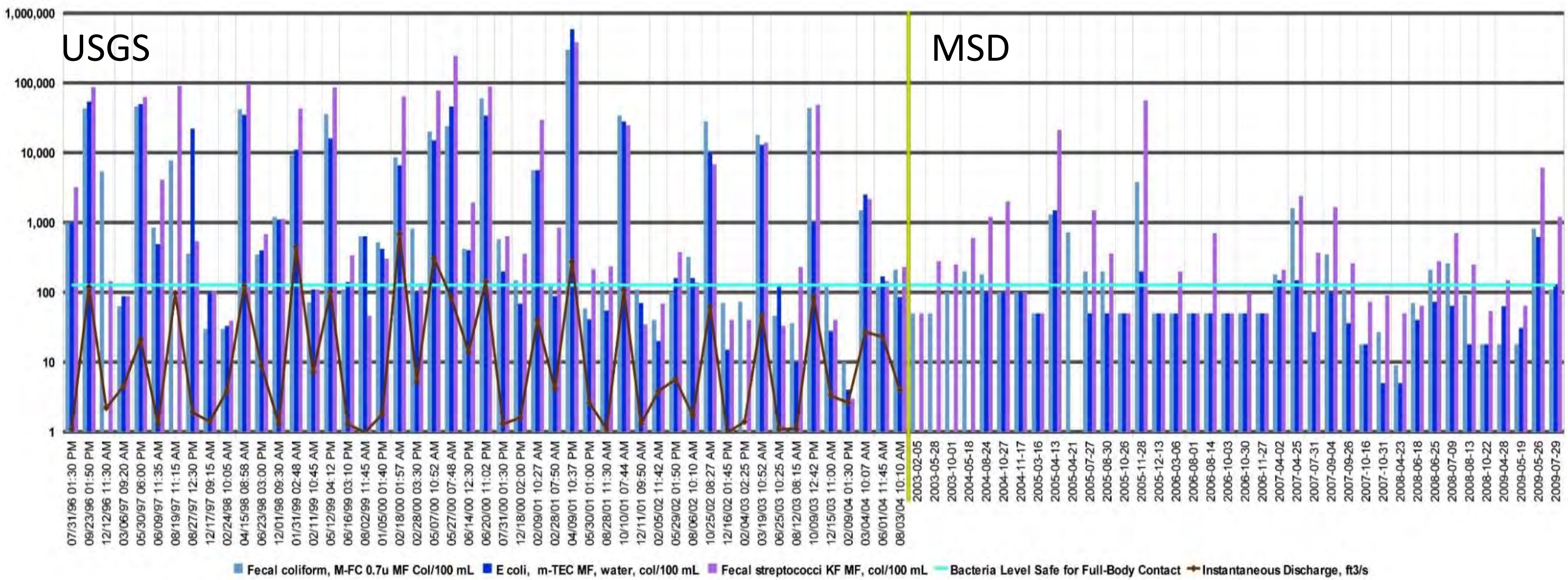
In 2010 Kiefer Creek was added to the 303(d) List of Impaired Waters of Missouri due to high levels of bacteria that violate the numeric criteria for Whole Body Contact Recreational Use B.



Since 2010 Missouri has dramatically increased the number of protected stream miles and improved protections on many streams. In the case of Kiefer Creek the Whole Body Contact B use on the main branch of the watershed has been upgraded to Whole Body Contact A in the time since the impairment was first recognized in 2010. In addition, the Spring Branch and Kiefer Spring Branch of the watershed have finally been afforded protections under the Clean Water Act. In 2009 we conducted an exhaustive search for scientifically valid data showing a continued impairment of Kiefer Creek, because the USGS data was deemed too dated to be used for designating an impairment. We were successful in our search and our submittal resulted in the long-overdue assignment of the recreational use of Kiefer Creek due to dangerously high levels of bacteria.

Water Quality Data Analysis

Water quality monitoring is precise in terms of determining the composition of a sample, however the context of the sample is extremely important to consider. In Kiefer Creek the data that first came to light in this process was the data collected by the USGS between 1996 and 2004 and data collected by MSD between 2003 and 2009. The data collected by the USGS shows extraordinarily high concentrations of bacteria in Kiefer Creek in many of the samples collected, whereas the data collected by MSD shows rare exceedances of acceptable bacteria levels. The USGS monitoring location was on the Kiefer Branch, upstream from its confluence with the Spring Branch; whereas the initial data from MSD was from a monitoring location on the main branch of Kiefer Creek, downstream from the confluence of the two main branches. However, it is also clear from data collected from the Spring Branch by MDNR and MSD, that the Spring Branch also frequently displays high concentrations of bacteria. The Spring Branch is also much less developed and smaller than the Kiefer Branch, which means that there will be more infiltration and less runoff and less overall water volume than the Kiefer Creek Branch. Therefore it is unlikely that the downstream location would allow for enough dilution to explain the stark difference in the data collected by the USGS and MSD.



Water Quality Assessment: Bacteria

Having ruled out the location of the samples as the primary factor effecting the differences in bacteria concentrations we looked to another likely culprit, precipitation. Precipitation is the source of every watershed, without rain watersheds would not exist, however it can also be the driving force behind the delivery of pollution to a stream channel. In order to study the relationship between the bacteria levels measured in Kiefer Creek and precipitation in the watershed, we compared stream flow measurements from the USGS flow monitoring station in the watershed at the times when samples were collected. This analysis shows a strong correlation between flow (cubic feet per second) and bacteria level and provides a sound explanation for the differences in the data collected by the USGS and MSD.

CFS	USGS Tests 1996-2004	E. coli Ave	Total Bacteria Ave	MSD Tests 2001-2012	E. coli Ave	Total Bacteria Average
0-1	2	328	242	3	75	331
1-2	15	1729	952	19	218	146
2-3	3	63	669	10	331	218
3-4	4	42	78	4	228	157
4-5	2	88	217	2	890	386
5-7.5	3	123	222	5	547	299
7.5-10	1	400	477	4	7833	3997
10–15	1	400	906	2	1950	995
15–25	2	25585	26573	1	21000	7933
25-50	3	7033	10297	1	1710	1605
50-100	4	15475	46042			
100-200	5	33400	51053			
> 200	4	155650	127116			
	49	18486	20373	51	3478	1607

Date	ID	CFS	E.Coli	Total Bacteria
12/16/02	USGS	0.97	15	125
10/3/06	MSD	0.97	50	150
8/2/99	USGS	0.98	640	1326
7/30/01	MSD	1	300	400
9/4/07	MSD	1	1650	2100
7/31/96	USGS	1.1	1000	5200
8/28/01	USGS	1.1	55	435
6/25/03	USGS	1.1	120	199
8/12/03	USGS	1.1	10	276
6/9/97	USGS	1.3	490	5426
12/1/98	USGS	1.3	1100	3400
6/16/99	USGS	1.3	140	590
7/31/00	USGS	1.3	200	1420
12/11/01	USGS	1.3	70	219
9/26/07	MSD	1.3	260	406
9/7/11	MSD	1.3	100	162
12/17/97	USGS	1.4	100	240
2/4/03	USGS	1.4	1	114
7/31/07	MSD	1.5	370	497
6/6/12	MSD	1.5	200	285
12/18/00	USGS	1.6	69	579
7/10/01	MSD	1.6	100	150
10/4/11	MSD	1.6	82	197
8/6/02	USGS	1.7	160	618
8/25/09	MSD	1.7	490	1006
9/16/09	MSD	1.7	360	1192
1/5/00	USGS	1.8	420	1240
10/26/05	MSD	1.8	50	100
10/16/07	MSD	1.8	73	109
10/22/08	MSD	1.8	54	90
8/2/11	MSD	1.8	200	479
8/27/97	USGS	1.9	22000	22895
8/1/06	MSD	1.9	50	150

High **Low**

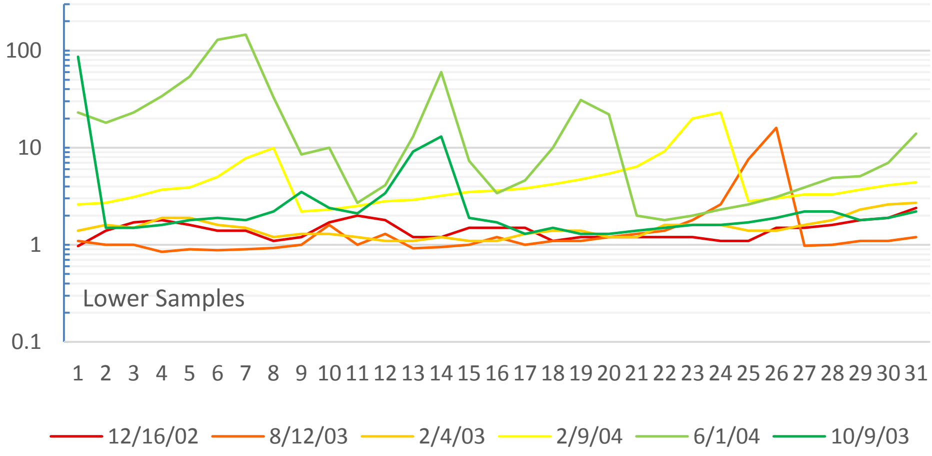
Date	ID	CFS	E.Coli	Total Bacteria
10/31/07	MSD	1.9	91	123
10/12/10	MSD	1.9	36	160
10/15/01	MSD	2	545	745
8/14/06	MSD	2	700	800
4/23/08	MSD	2	50	64
7/6/11	MSD	2	340	1046
12/12/96	USGS	2.2	144	5688
8/30/05	MSD	2.2	360	610
8/10/10	MSD	2.2	330	586
4/3/12	MSD	2.2	27	237
7/7/10	MSD	2.4	270	677
6/6/11	MSD	2.4	200	532
5/28/05	MSD	2.4		770
8/13/08	MSD	2.5	250	359
5/30/01	USGS	2.6	41	320
2/9/04	USGS	2.6	4	17
7/26/10	MSD	2.6	600	1147
6/18/08	MSD	2.7	64	174
4/13/10	MSD	2.8	10	20
7/29/09	MSD	3	1200	1442
5/28/03	MSD	3.1	280	330
12/15/03	USGS	3.3	28	188
10/1/03	MSD	3.5	250	350
9/15/10	MSD	3.5	280	636
2/5/02	USGS	3.8	20	129
2/24/98	USGS	3.9	33	102
8/3/04	USGS	4	86	526
5/17/11	MSD	4	100	250
2/28/01	USGS	4.1	88	1060
6/25/08	MSD	4.2	280	563
7/27/05	MSD	4.4	1500	1750
3/6/97	USGS	4.5	88	239
2/28/00	USGS	5.3	100	1060
8/24/04	MSD	5.5	1200	1480

Date	ID	CFS	E.Coli	Total Bacteria
7/9/08	MSD	5.6	700	1024
5/29/02	USGS	5.7	160	645
4/6/10	MSD	5.8	27	47
4/2/07	MSD	7	210	540
2/11/99	USGS	7.1	110	292
5/18/04	MSD	7.3	600	800
5/8/12	MSD	7.6	3500	4390
10/27/04	MSD	8.3	2000	2200
10/6/09	MSD	8.4	18000	32610
6/23/98	USGS	8.9	400	1430
4/21/05	MSD	9.9		771
4/25/07	MSD	11	2400	4150
6/14/00	USGS	14	400	2720
4/5/11	MSD	15	1500	1821
4/13/05	MSD	17	21000	23800
5/30/97	USGS	21.1	51000	159000
6/1/04	USGS	23	170	436
3/4/04	USGS	27	2500	6170
4/26/10	MSD	29	1710	3210
2/9/01	USGS	40	5600	41200
3/19/03	USGS	46	13000	45300
10/25/02	USGS	62	10000	44800
5/27/00	USGS	83	46000	310000
10/9/03	USGS	86	499	93499
8/19/97	USGS	97	5400	104200
5/12/99	USGS	101	16000	138000
10/10/01	USGS	108	28000	86800
9/23/96	USGS	120	54000	184000
4/15/98	USGS	125	35000	174000
6/20/00	USGS	143	34000	183000
4/9/01	USGS	272	590000	1270000
5/7/00	USGS	306	15000	113000
1/31/99	USGS	444	11000	63200
2/18/00	USGS	685	6600	79200

The USGS samples were collected during a wider range of hydrologic conditions in Kiefer Creek, the data collected by MSD was primarily collected during low and normal flow conditions. The comparison of these datasets also rendered some interesting variations in the overall pattern that we decided to look into further. by studying the flow characteristics leading up to tests that showed either higher and lower bacteria levels relative to flow.

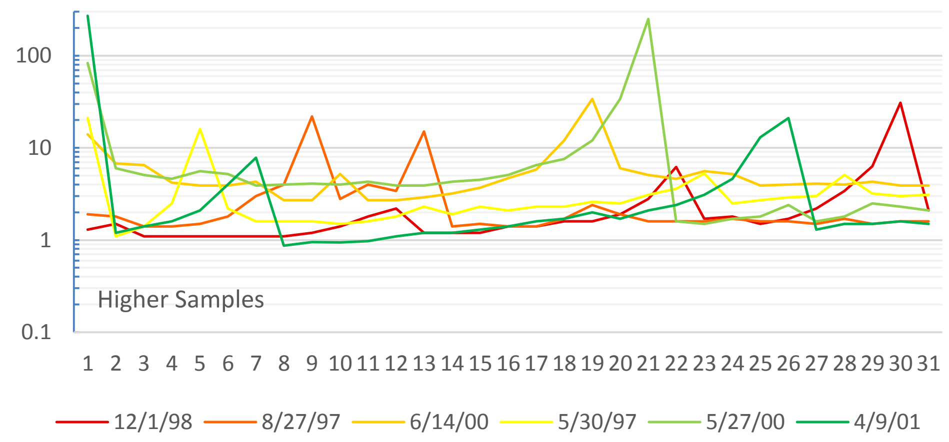
	Lower Samples						Higher Samples					
Date	12/16/02	8/12/03	2/4/03	2/9/04	6/1/04	10/9/03	12/1/98	8/27/97	6/14/00	5/30/97	5/27/00	4/9/01
E.Coli	15	10	1	4	170	499	1100	22000	400	51000	46000	590000
Fecal Col.	70	36	73	10	120	44000	1200	355	420	45500	24000	300000
Fecal Str.	40	230	40	3	146	49000	1100	540	1900	62500	240000	380000
Total Bacteria	125	276	114	17	436	93499	3400	22895	2720	159000	310000	1270000
CFS	0.97	1.1	1.4	2.6	23	86	1.3	1.9	14	21.1	83	272

To analyze the flow trends for high and low variations from above in the following graphs contain the mean daily CFS data from the USGS for the CFS at the time of the sample (1) and the 30 days prior to the sample.



In the graphs it is notable that most of the flow trends on the low variation graph show a falling flow, while most of the flow trends on the high variation graph show a rising flow. The low variation sample with the highest bacteria concentration shows an increasing flow and the high variation sample with the lowest bacteria concentrations shows a decreasing flow. The trend based on this subset of the sampling data appears to reinforce the connection between flow and bacteria concentration. This analysis also helps to understand when Kiefer Creek is the least safe for recreation. Lower bacteria concentrations seem to prevail when the flow has remained low and stable for more than 6 days, while higher bacteria concentrations are found when flow has increased in the 6 days leading up to the test.

To enhance this analysis, the study was expanded to incorporate the precipitation data leading up to and on the sample dates. This analysis was conducted on the data collected by the USGS on the Kiefer Spring Branch and MSD on the Kiefer Main Branch between 1996 and 2009. Precipitation data was collected primarily from records provided by MSD, which were available as far back as the last quarter of 1998, for earlier samples historical data from the weather station south of Lambert Airport were collected from the website wunderground.com were used. In the following table the rainfall has been tracked not only on the day of the test, but also on the 5 days preceding when the sample was taken, in order to better understand the duration of high bacteria concentrations.



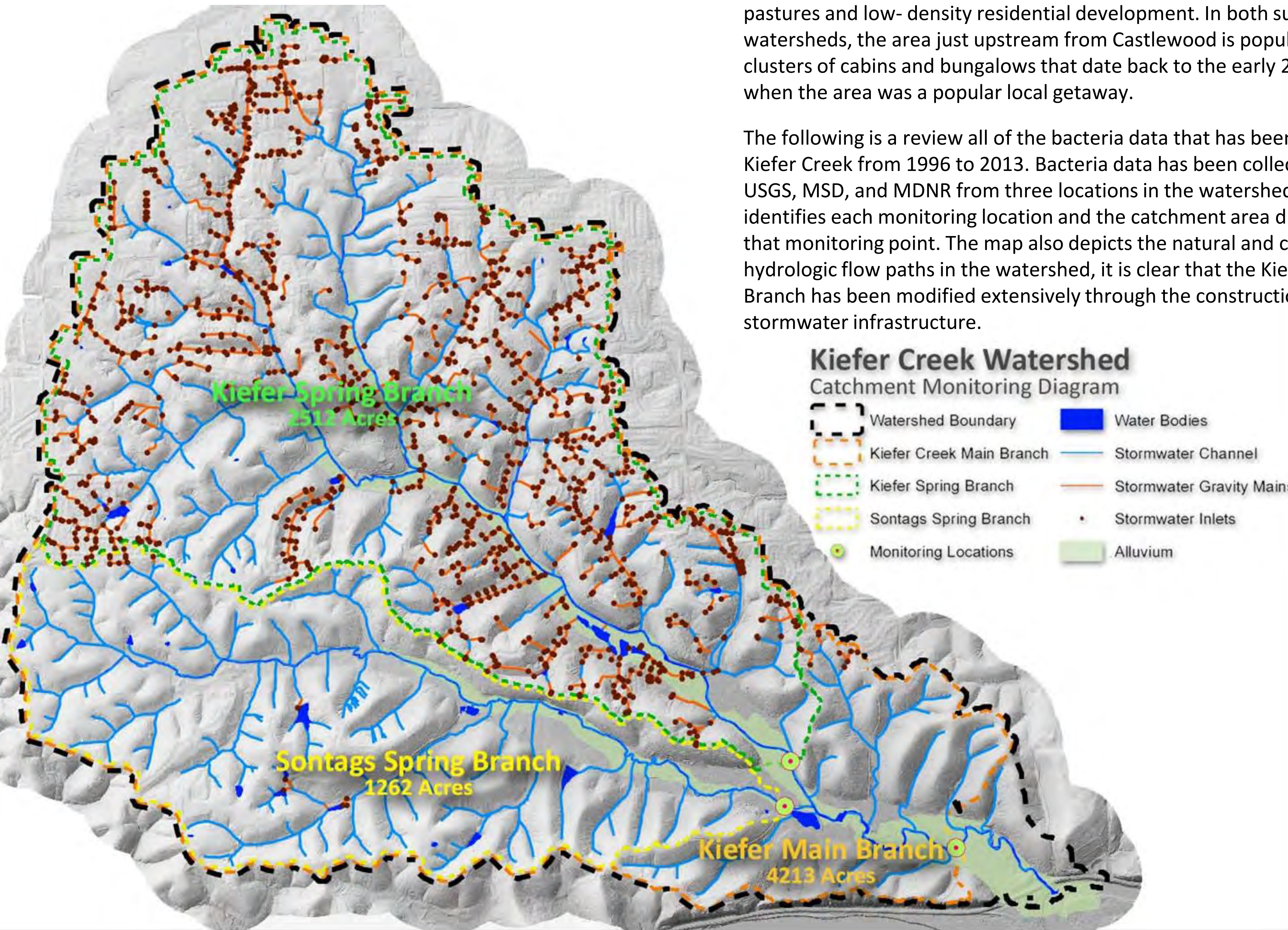
Precip: .01-.5 | .5-1 | 1-1.5 | 1.5-2 | 2-3 | 3-4 | 4+

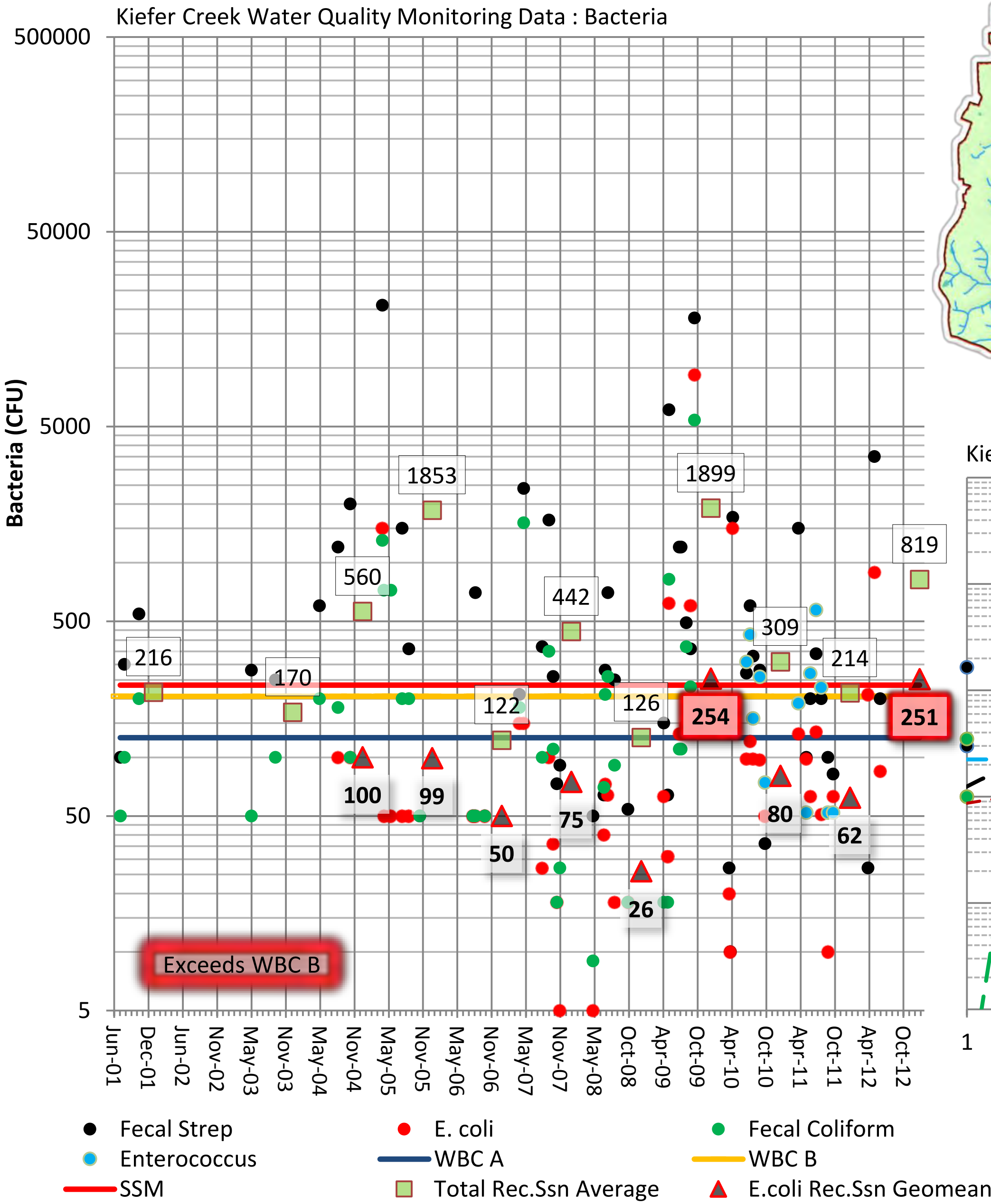
Entity	Date	Bacteria CFU: E. coli	Fecal Coli.	Fecal Strep.	Total Bact. CFU	Day of Test	Rainfall in. by days before test: 1	2	3	4	5	6-Day Total	Inst. CFS	Mean Daily CFS
USGS	4/9/01	590000	300000	381000	1271000	2.17	0	0	0	0	0	2.17	274	19
USGS	5/27/00	46000	24000	244000	314000	1.4	1.52	0.1	0	0.14	0.35	3.51	83	34
USGS	9/23/96	54000	43000	87000	184000	1.23	0	0	0	0	0	1.23	120	65
USGS	6/20/00	34000	60000	89000	183000	0.87	0	0	0.5	1.14	0	2.51	143	9.2
USGS	4/15/98	35000	42000	97000	174000	0.51	0	0.74	0	0	0	1.25	125	31
USGS	5/30/97	50000	46000	62500	158500	0.67	0	0.02	0.04	0.6	0.62	1.95	21	6.7
USGS	5/12/99	16000	36000	86000	138000	2.23	0.11	0	0	0	0	2.34	101	22
USGS	5/7/00	15000	20000	78000	113000	4.45	0.25	0.04	0	0	0.33	5.07	306	251
USGS	8/19/97		7800	91000	98800	1.25	0	0.35	0	0.9	0.06	2.56	97	22
USGS	10/9/03	1000	44000	49000	94000	0.65	0	0	0	0	0	0.65	86	21
USGS	10/10/01	28000	34000	24800	86800	1.67	0	0	0	0.01	1.03	2.71	108	19
USGS	2/18/00	6600	8600	64000	79200	1.04	0.56	0	0	0	0.29	1.89	685	76
USGS	1/31/99	11000	9200	43000	63200	0.52	1.15	0	0.08	0	0	1.75	444	35
MSD	11/28/05	200	3800	56000	60000	1.06	0.85	0	0	0	0	1.91	35	44
USGS	3/19/03	13000	18000	14000	45000	0.99	0.05	0	0	0	0	1.04	46	20
USGS	10/25/02	10000	28000	6800	44800	0.63	0	0	0	0	0	0.63	62	12
USGS	2/9/01	5600	5600	29500	40700	0.72	0	0	0.53	0	0	1.25	40	9.5
MSD	10/6/09	9210	5400	18000	32610	0.44	0	0	0	0.01	0.84	1.29	17	8.4
MSD	4/13/05	1500	1300	21000	23800	0.16	0.93	0.45	0	0	0	1.54	18	17
USGS	8/27/97	22000	360	540	22900	0	0.06	0	0	0	0	0.06	1.9	1.6
MSD	5/26/09	620	820	6100	7540	0.13	1.25	0.06	0.05	0	0	1.49	9.6	12
USGS	3/4/04	1500	2500	2170	6170	0.78	0.61	0	0	0.06	0	1.45	27	29
USGS	12/12/96		5400	144	5544	0.02	0	0	0	0	0	0.02	2.2	2.3
USGS	6/9/97	490	840	4100	5430	0	0.02	0	0.09	0	0	0.11	1.3	1.2
USGS	7/31/96	1000	1000	3200	5200	0	0.01	0.91	1.78	0.02	0	2.72	1.1	1.2
MSD	4/25/07	150	1600	2400	4150	0.22	0.49	0	0	0	0	0.71	12	11
USGS	12/1/98	1100	1200	1120	3420	0	0.23	0	0	0	0	0.23	1.3	1.4
USGS	6/14/00	400	420	1940	2760	0.06	0.01	0.58	0.44	0	0	1.09	14	5.7
MSD	10/27/04	100	100	2000	2200	0.05	0.45	0	0	0.21	0	0.71	9.1	8.3
MSD	9/4/07	100	350	1650	2100	0	0	0	0	0	0	0	0.8	1
MSD	7/27/05	50	200	1500	1750	0	0.32	0	0	0	0	0.32	5.5	4.4
MSD	8/24/04	100	180	1200	1480	0	0.3	0	0	0.52	0.18	1	5.2	5.5
MSD	7/29/09	132	110	1200	1442	0.17	0	0	0.05	0	0.13	0.35	2.6	3
USGS	6/23/98	400	350	680	1430	0	0.01	1.39	0.49	0	0.01	1.9	8.9	8.7
USGS	7/31/00	200	580	640	1420	0	0	0.67	0.74	0	0	1.41	1.3	1.8
USGS	8/2/99	640	640	46	1326	0	0	0	0	0	0	0	0.98	1.2
USGS	1/5/00	420	520	304	1244	0	0	0.52	0	0	0	0.52	1.8	1.9
MSD	9/16/09	602	230	360	1192	0	0.13	0	0	0	0	0.13	1.5	1.7
USGS	2/28/01	88	130	840	1058	0	0.09	0	0.01	1.23	0.4	1.73	4.1	3.1
USGS	2/28/00	100	820	135	1055	0	0	0	0	0	0	0	5.3	6.3
MSD	7/9/08	64	260	700	1024	0.48	0.16	0	0	0	0	0.64	5.1	5.6
MSD	8/25/09	146	370	490	1006	0	0	0	0	0.01	0.96	0.97	1.6	1.7
MSD	8/14/06	50	50	700	800	0	0	0	0	0.19	0.37	0.56	1.8	2
MSD	5/18/04		200	600	800	0	0	0	0	0.42	1.08	1.5	2.6	7.3
MSD	4/21/05		720		720	0.43	0.22	0	0	0	0	0.65	13	9.9

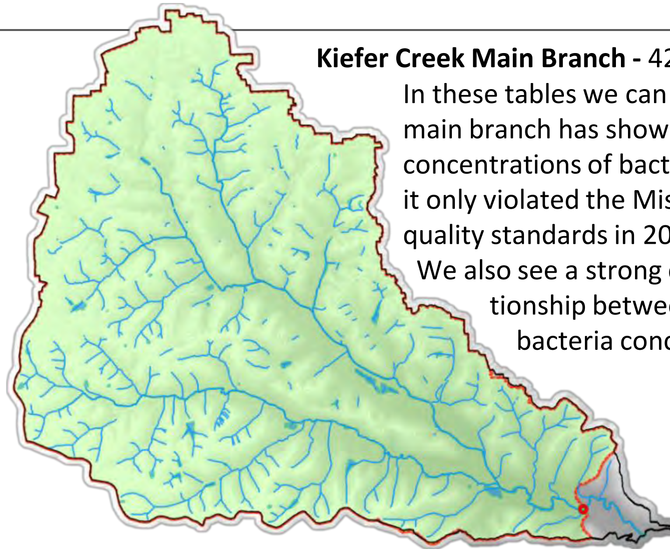
Entity	Date	Bacteria CFU: E. coli	Fecal Coli.	Fecal Strep.	Total Bact. CFU	Day of Test	Rainfall in. by days before test: 1	2	3	4	5	6-Day Total	Inst. CFS	Mean Daily CFS
USGS	5/29/02	160	100	380	640	0	0.06	0	0.01	0	0.08	0.15	5.7	5
USGS	8/6/02	160	320	138	618	0.11	0	0	0	0	0	0.11	1.7	1.8
MSD	8/30/05	50	200	360	610	0	0	0	0	0.51	1.01	1.52	2.57	2.2
USGS	6/16/99	140	110	340	590	0	0	0	0	0	0	0	1.3	1.1
USGS	12/18/00	69	150	356	575	0	0.01	0.08	0.14	0.07	0.09	0.39	1.6	2.1
MSD	6/25/08	73	210	280	563	0	0.05	0	0.11	0.02	0.15	0.33	2.4	2.5
MSD	4/2/07	150	180	210	540	0	0	0.01	0.01	0	0.03	0.05	7.2	7
USGS	8/3/04	86	210	230	526	0	0	0	0	2.26	0	2.26	4	4
MSD	7/31/07	27	100	370	497	0	0	0	0	0	0	0	1.3	1.5
USGS	6/1/04	170	120	146	436	0.01	0.1	0.18	0	0.01	0.08	0.38	23	14
USGS	8/28/01	55	140	235	430	0.01	0	0	0	0	0	0.01	1.1	1.1
MSD	9/26/07	36	110	260	406	0	0.01	0.01	0	0.01	0	0.03	1.4	1.3
MSD	8/13/08	18	91	250	359	0	0	0	0	0	0	0	2.4	2.5
MSD	10/1/03		100	250	350	0.01	0	0.01	0.02	0.01	0.01	0.06	3.5	3.5
MSD	5/28/03		50	280	330	0	0	0.01	1.22	0.29	0	1.52	2.8	3.1
USGS	5/30/01	41	59	215	315	0	0	0	0	0.03	0.23	0.26	2.6	4.6
MSD	11/17/04	100	100	100	300	0	0	0	0	0	0	0	2.8	2.8
MSD	3/6/06	50	50	200	300	0.05	0.26	0	0	0	0	0.31	2	2.1
USGS	2/11/99	110	72	110	292	0	0	0	0	1.65	1.28	2.93	7.1	11
USGS	8/12/03	10	36	230	276	0	0	0	0	0	0	0	1.1	0.99
USGS	3/6/97	88	63	88	239	0	0.02	0	0	0	0.12	0.14	4.5	4.5
USGS	12/17/97	100	30	106	236	0	0	0	0	0	0	0	1.4	1.4
MSD	4/28/09	63	18	150	231	0	0.2	0	0	0	0	0.2	4.5	4.8
USGS	12/11/01	70	110	35	215	0	0	0	0	0	0.01	0.01	1.3	1.3
MSD	10/30/06	50	50	100	200	0	0	0	0.79	0.52	0.41	1.72	1.7	1.6
USGS	6/25/03	120	46	33	199	0	0	0	0	0	0	0	1.1	13
USGS	12/15/03	28	120	40	188	0	0	0.07	0	0	0.13	0.2	3.3	2.9
MSD	6/18/08	40	70	64	174	0	0	0	0	0	0.21	0.21	5.1	5.6
MSD	3/16/05	50	50	50	150	0	0	0	0	0	0	0	2	1.6
MSD	10/26/05	50	50	50	150	0.01	0	0	0.01	0	0	0.02	1.7	1.8
MSD	12/13/05	50	50	50	150	0	0	0.01	0.09	0	0	0.1	1.8	1.7
MSD	8/1/06	50	50	50	150	0	0	0	0.2	0	0	0.2	2	1.9
MSD	10/3/06	50	50	50	150	0	0.01	0	0.01	0	0.01	0.03	0.92	0.97
MSD	11/27/06	50	50	50	150	0	0	0	0	0	0	0	1.8	1.9
USGS	2/5/02	20	40	69	129	0	0	0	0	0	1.08	1.08	3.8	4
USGS	12/16/02	15	70	40	125	0	0	0	0.05	0	0	0.05	0.97	1.5
MSD	10/31/07	5	27	91	123	0.01	0.03	0.25	0	0	0.01	0.3	2	1.9
USGS	2/4/03	1	73	40	114	0	0.02	0	0	0.08	0	0.1	1.4	1.5
MSD	5/19/09	31	18	64	113	0	0	0	0.03	1.05	0.02	1.1	2.4	2.5
MSD	10/16/07	18	18	73	109	0	0.01	0.01	0	0.01	0	0.03	1.8	1.8
USGS	2/24/98	33	30	39	102	0	0	0	0	0	0.02	0.02	3.9	3.7
MSD	2/5/03		50	50	100	0	0	0.02	0	0	0.08	0.1	1.3	1.3
MSD	10/22/08	18	18	54	90	0.09	0	0	0	0	0	0.09	1.8	1.8
MSD	4/23/08	5	9	50	64	0	0.09	0	0	0.05	0.92	1.06	2.2	2
USGS	2/9/04	10	4	3	17	0	0	0	0	0.11	0	0.11	2.6	3

Upstream from Castlewood the watershed splits into two sub-basins, the Kiefer Spring Branch to the northwest and the Spring Branch to the southwest. The Kiefer Spring Branch has significant impervious surfaces due to the amount of suburban residential and big box commercial development in the catchment. By contrast, the Spring Branch sub-watershed is primarily a balance of undeveloped greenspace, horse pastures and low- density residential development. In both sub-watersheds, the area just upstream from Castlewood is populated with clusters of cabins and bungalows that date back to the early 20th century, when the area was a popular local getaway.

The following is a review all of the bacteria data that has been collected in Kiefer Creek from 1996 to 2013. Bacteria data has been collected by the USGS, MSD, and MDNR from three locations in the watershed. This map identifies each monitoring location and the catchment area draining to that monitoring point. The map also depicts the natural and constructed hydrologic flow paths in the watershed, it is clear that the Kiefer Spring Branch has been modified extensively through the construction of stormwater infrastructure.

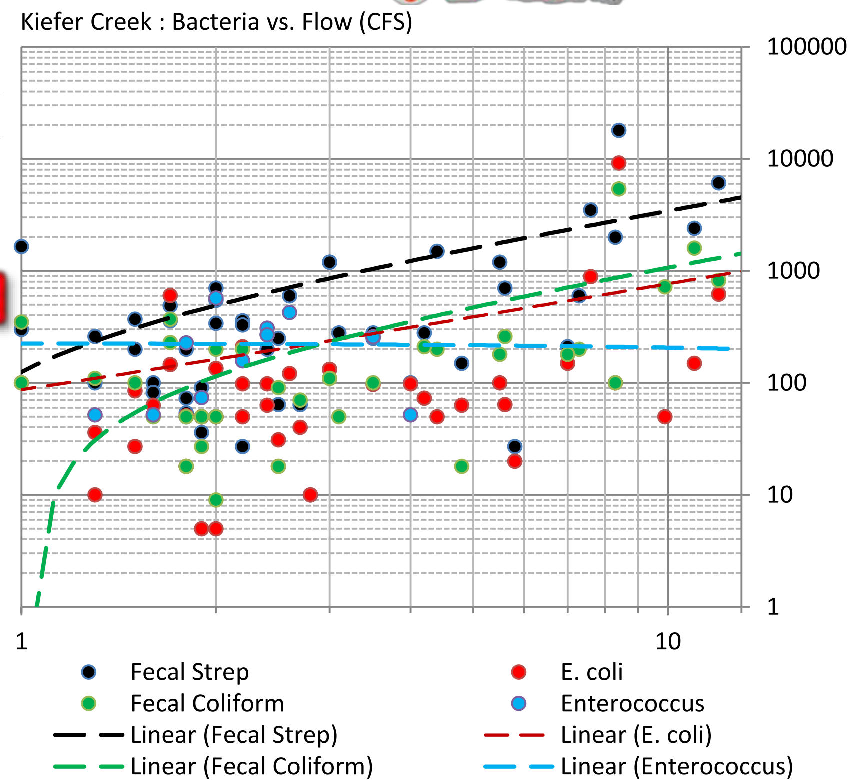


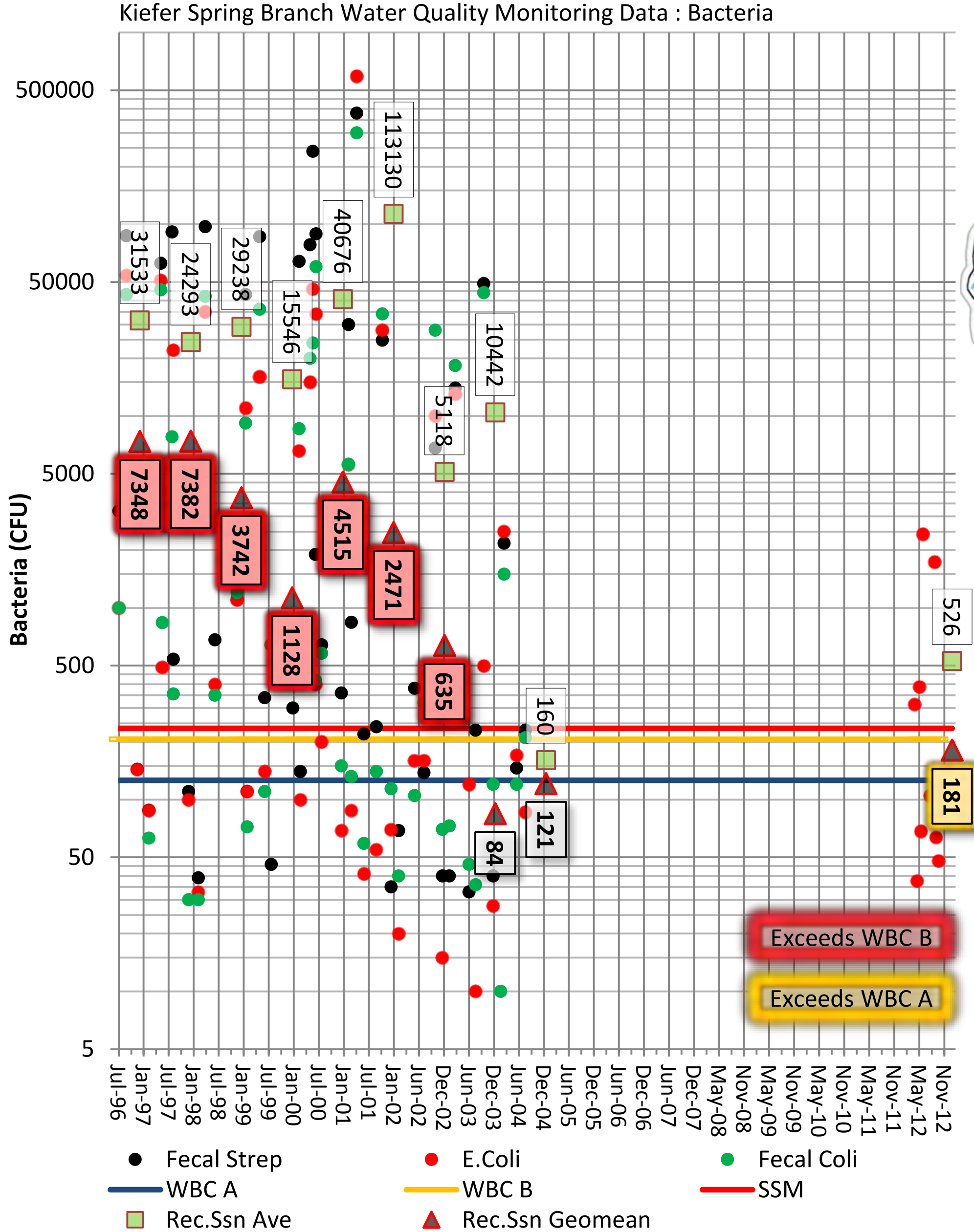


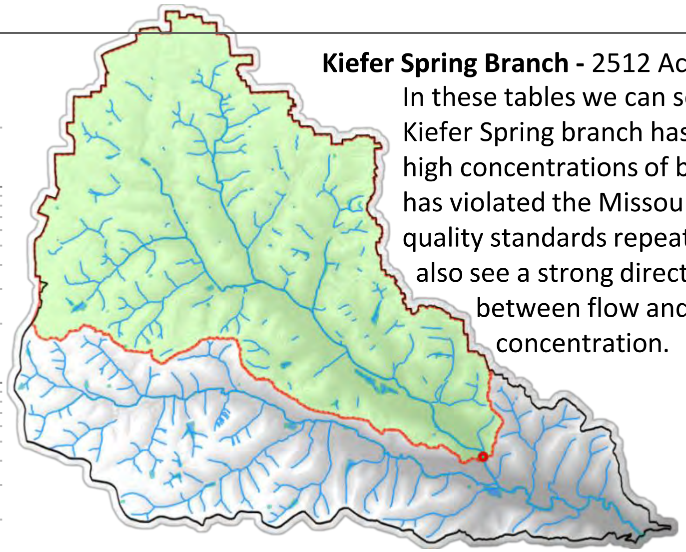


Kiefer Creek Main Branch - 4213 Acres

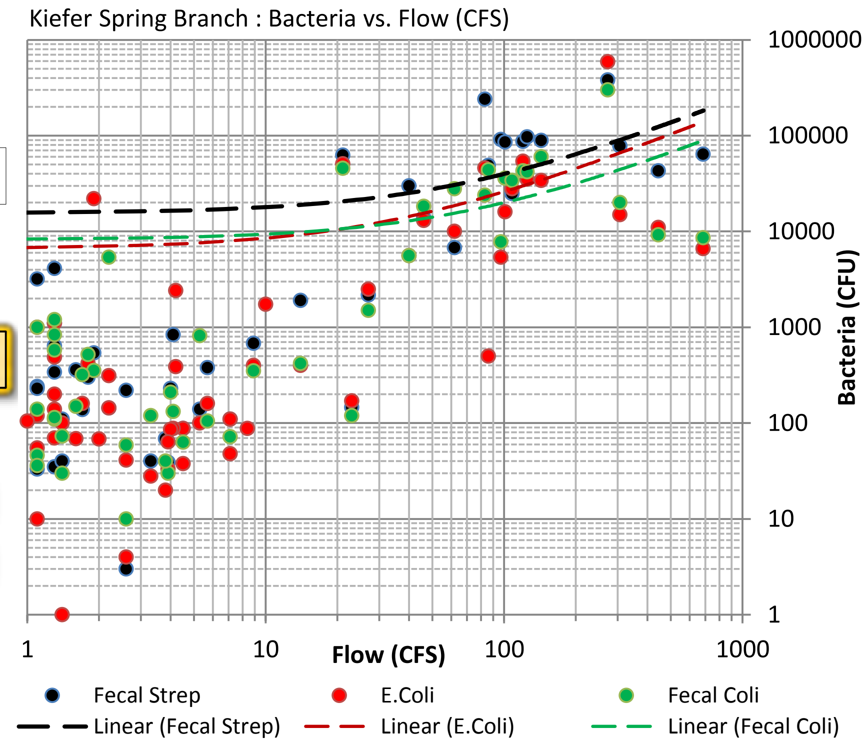
In these tables we can see that the main branch has shown very high concentrations of bacteria, however it only violated the Missouri water quality standards in 2009 and 2012. We also see a strong direct relationship between flow and bacteria concentrations.

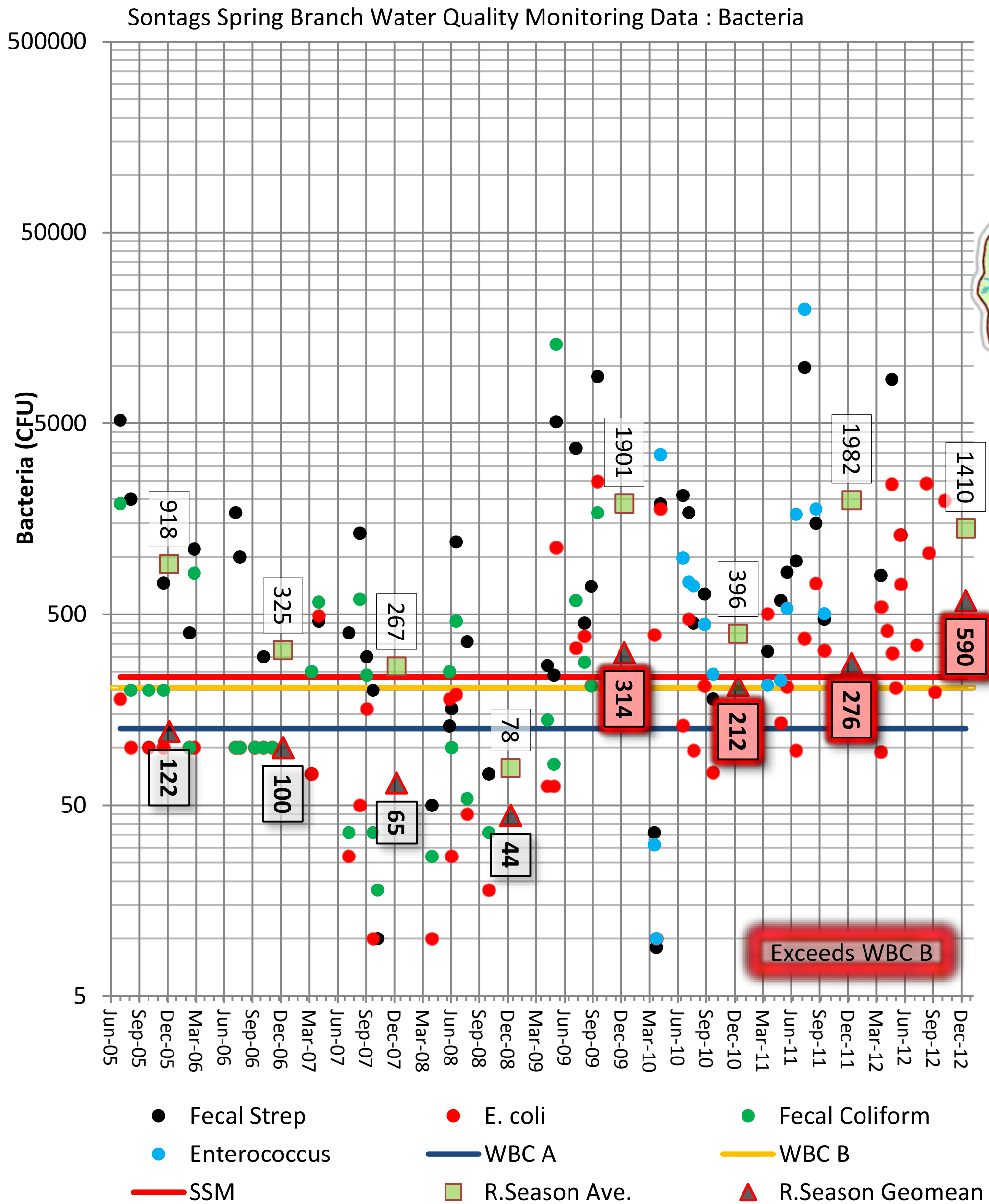


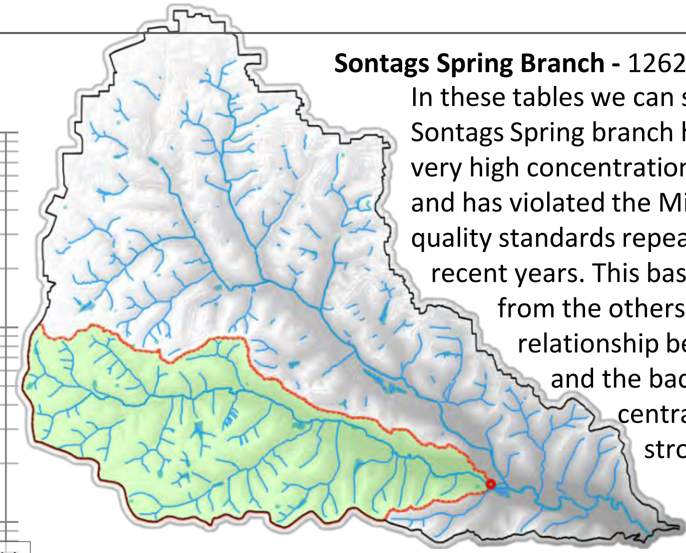




Kiefer Spring Branch - 2512 Acres
In these tables we can see that the Kiefer Spring branch has shown very high concentrations of bacteria, and has violated the Missouri water quality standards repeatedly. We also see a strong direct relationship between flow and the bacteria concentration.

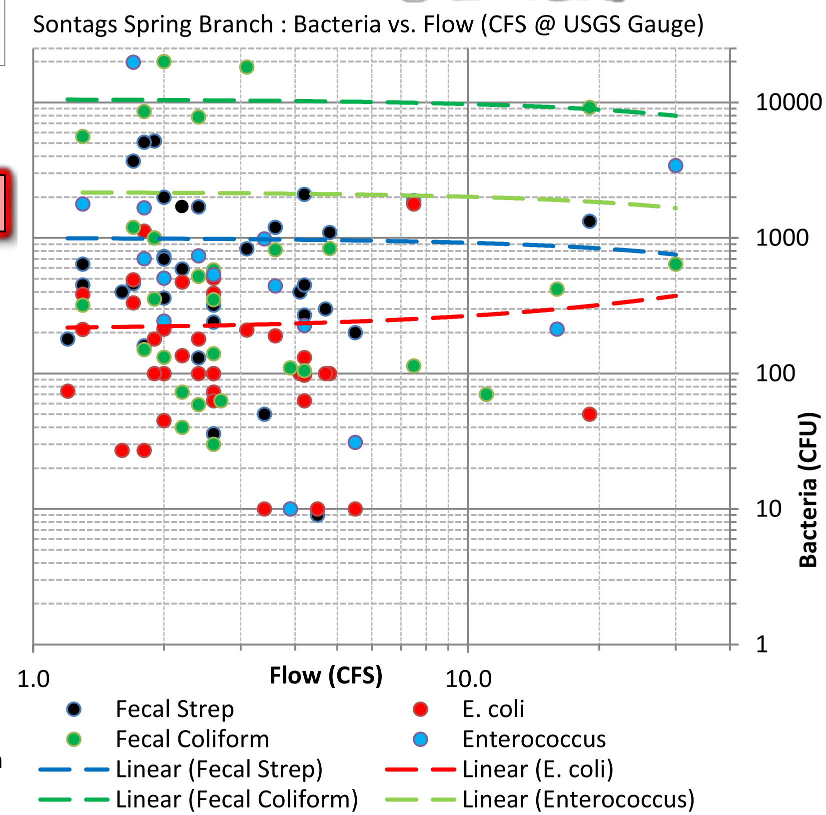




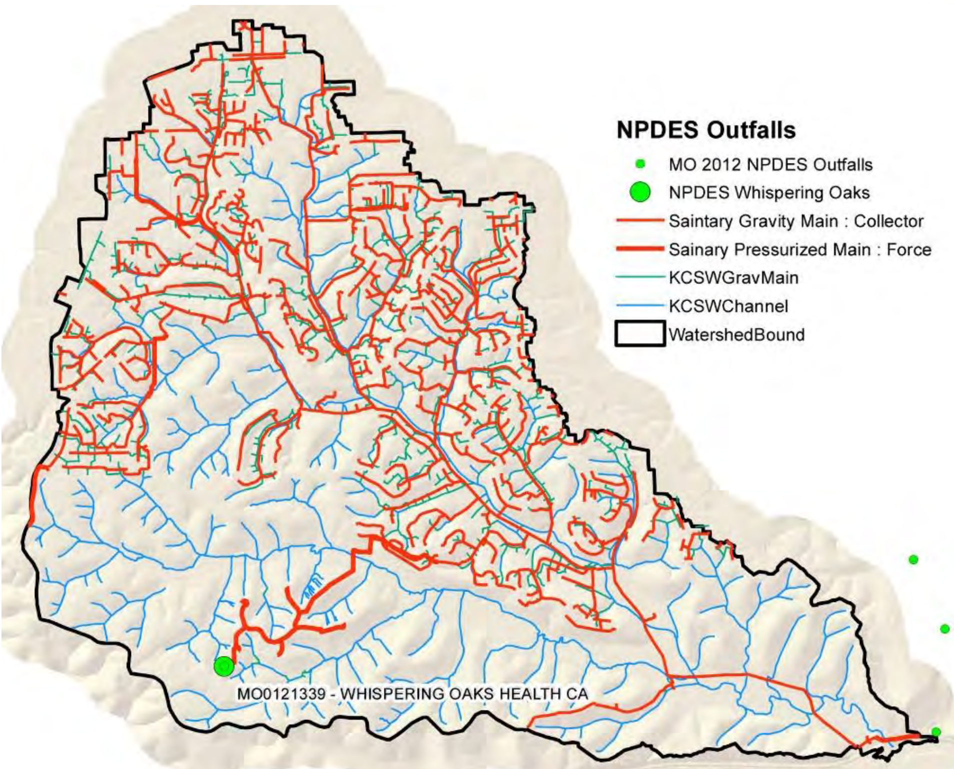


Sontags Spring Branch - 1262 Acres

In these tables we can see that the Sontags Spring branch has shown very high concentrations of bacteria, and has violated the Missouri water quality standards repeatedly in recent years. This basin is different from the others in that the relationship between flow and the bacteria concentration is not as strong.

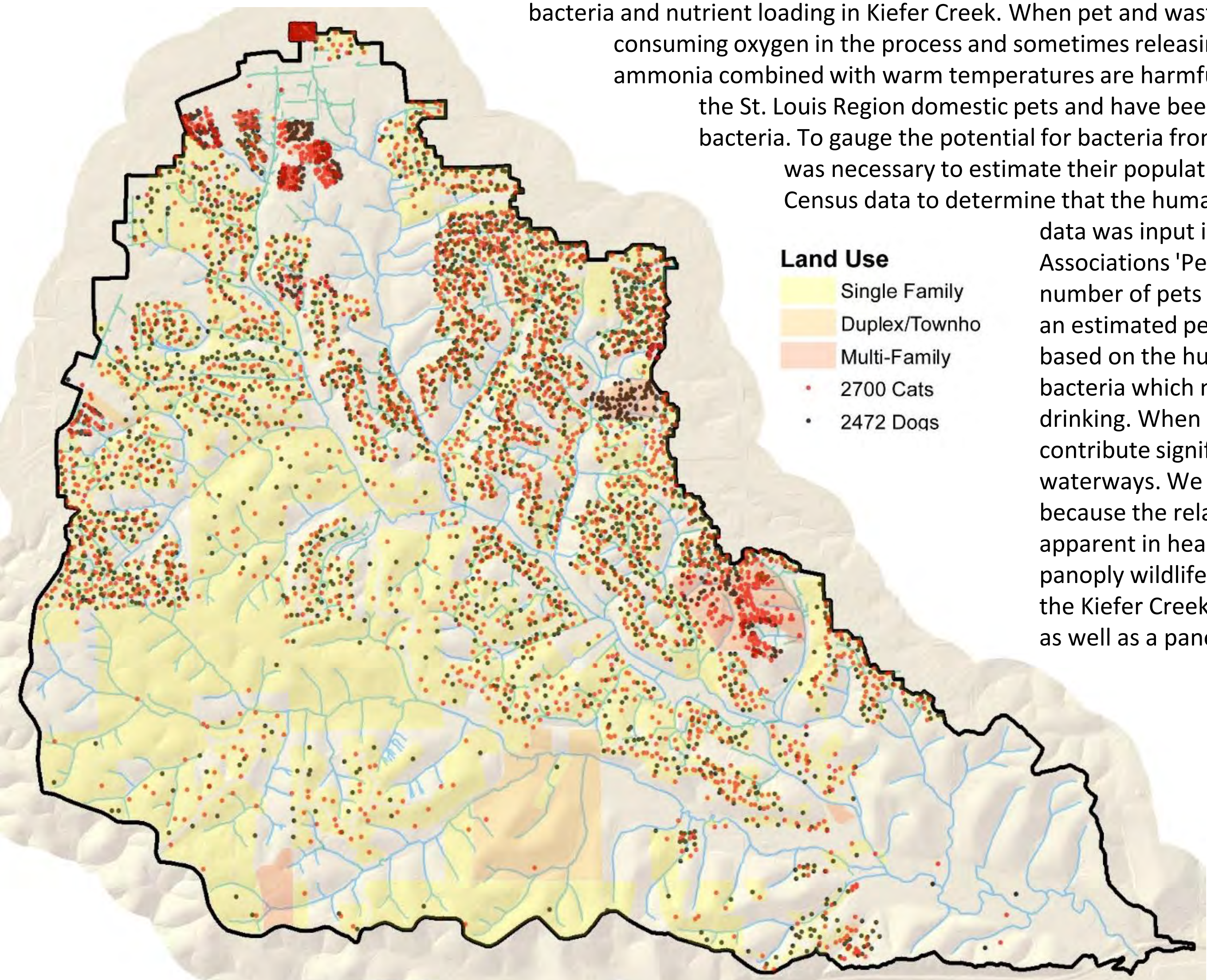


. We reviewed the Missouri NPDES (National Polllution Discharge Elimination System) dataset to identify any active point sources in the watershed, revealing one permitted outfall with a permit that expired in 2000. Early in the watershed planning process we investigated this permit to determine if it could be producing effluent contributing bacteria to the watershed, revealing that this facility has been connected to the centralized sewer system since 2000. Additionally this facility would have discharged to the Spring Branch which was not part of the drainage monitored by the USGS which showed such extraordinarily high bacteria levels during monitoring prior to 2000.



In addition, we reviewed a regional map of CSOs (Combined Sewer Overlfows) and SSOs (Separate Sewer Overflows), which are a common source of bacteria in local streams, and found no CSOs or SSOs in the watershed.

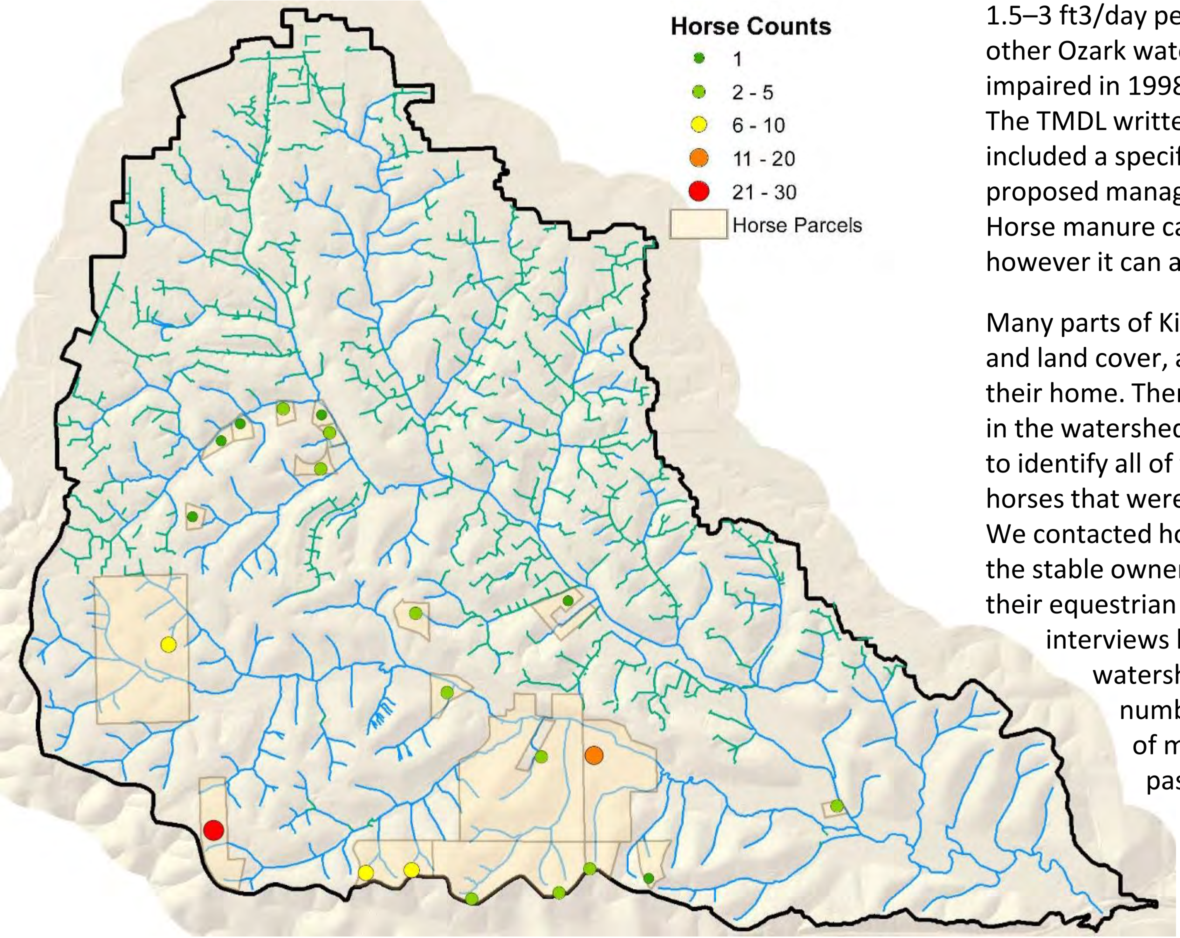
Robert W. Adler, “CPR Perspective: TMDLs, Nonpoint Source Pollution, and the Goals of the Clean Water Act,”
Center for Progressive Reform, 2013, <http://www.progressivereform.org/persptmdls.cfm> (accessed January 8, 2015)
Missouri Department of Natural Resources, Department of Environmental Quality, Water Protection Program, *MO 2012 National Pollutant Discharge Elimination Systems (NPDES) Outfalls*, [FTP-Shapefile], 2012, <ftp://msdis.missouri.edu/pub/Environment_Conservation/MO_2012_National_Pollutant_Discharge_Elimination_System_Outfalls_shp.zip>
Constructed Sewer Overflows Map (Metropolitan St. Louis Sewer District: 2012) http://www.stlmsd.com/sites/default/files/education/448847.PDF (Layout Modified)



Domesticated dogs and cats are not native to the watershed, and their waste is assumed to be part of the bacteria and nutrient loading in Kiefer Creek. When pet and waste is washed into streams, it decays, consuming oxygen in the process and sometimes releasing ammonia. Low oxygen levels and ammonia combined with warm temperatures are harmful to aquatic life. In the urban watersheds in the St. Louis Region domestic pets and have been identified as common non-point sources of bacteria. To gauge the potential for bacteria from pets to cause the impairment of Kiefer, it was necessary to estimate their population in the watershed. We used 2010 US Census data to determine that the human population of watershed is 11005. This data was input into the American Veterinary Medicine Associations 'Pet Ownership Calculator' to the estimate number of pets in the watershed. The calculator returned an estimated pet population of 2472 dogs and 2700 cats based on the human population. The waste also carries bacteria which makes water unsafe for swimming or drinking. When this waste isn't properly managed it can contribute significantly to high bacteria levels in our waterways. We ruled out wildlife waste as a major source because the relatively small impact of wildlife waste is apparent in healthy watersheds which typically support panoply wildlife without violating water quality criteria. In the Kiefer Creek Watershed there are many pets and horses as well as a panoply of wildlife, all of which contribute to the bacteria that is present in the watershed. As a watershed changes from natural to developed and its natural land cover is reduced, its capacity to digest the waste from animals diminishes, whether they are native wild animals, or domesticated animals brought in with development. In our later efforts to develop a watershed model, wildlife waste and urban runoff were accounted for in pathogen loading analyses.

U.S. Census Bureau, *MO 2010 TIGER Census Tracts*, [FTP-Shapefile], 2010, <ftp://msdis.missouri.edu/pub/Administrative_Political_Boundaries/MO_2010_TIGER_Census_Tracts_shp.zip>
AVMA , *U.S. Pet Ownership Statistics: Pet Calculator*, 2015, <https://www.avma.org/KB/Resources/Statistics/Pages/Market-research-statistics-US-pet-ownership.aspx>
Donald H. Wilkison and Jerri V. Davis, U.S. Department of the interior, U.S. Geological Survey, *Occurrence and Sources of Escherichia coli in Metropolitan St. Louis Streams, October 2004 through September 2007*, Scientific Investigations Report 2010-5150 (Reston, VA: U.S. Geological Survey, 2010), 28, Figure 12.
Criss, Water Quality Report for Small Streams of the St. Louis Area, 3.

Our assessment evaluated the potential for bacterial non-point sources typical to both urban and rural regions of the Meramec Basin that are represented within the watershed. In the rural Ozarks common non-point bacteria sources include livestock, horses and broken or poorly designed septic systems. The Kiefer Creek watershed does not contain any livestock operations, however there are many horses in the watershed at two commercial stables and on over a dozen residential parcels. Horses are a common non-point source of bacteria in watersheds across the United States.



Each individual horse produces an average of 9 tons of manure and 3.5 tons of urine per year. "Horse manure production is variable and depends on horse physiology, horse management, and manure collection practices. A 1000 pound (lb) horse produces 31 lb of feces and 2.4 gal. of urine, which adds up to 51 lb/day. The amount of feces and urine ranges between 42 and 68 lb/day for 900–1300 lb horses. In addition to feces and urine, about 8 lb–15 lb of spoiled bedding is disposed per day per animal. Based on the above listed ranges for feces and urine and spoiled bedding, one horse produces a total of 50–83 lb/day. This equals about 1.5–3 ft3/day per horse."Horse waste has been known to cause issues in other Ozark waterways, such as the Jack's Fork, which was listed as impaired in 1998 for recreational use due to bacteria in 1998 and 2002. The TMDL written to address the impairment of the Jack's Fork River included a specific assessment of potential waste loading from horse and proposed management measures to reduce this source of bacteria. Horse manure can cause problematic imbalances in water quality, however it can also be properly managed and utilized as a resource.

Many parts of Kiefer Creek are still quite rural in terms of the land use and land cover, allowing for many watershed residents to keep horses at their home. There are also commercial horse stables and training areas in the watershed. Initially we used field observations and aerial imagery to identify all of the pastures and visible horses, however this excluded horses that were stabled or obscured when the imagery was collected. We contacted horse owners in the watershed with letters and met with the stable owners, to develop a more accurate estimate and learn about their equestrian waste management practices. Our imagery review and interviews led to an informed estimate of 116 horses in the watershed. We observed that the commercial stables had a high number of the total horses in the watershed with some form of manure management, but the most issues with exhausted pastures and erosion. Residential owners have employed less effective manure management practices, however their horses tended to have access to more area of pasture per horse resulting in healthier pastures.

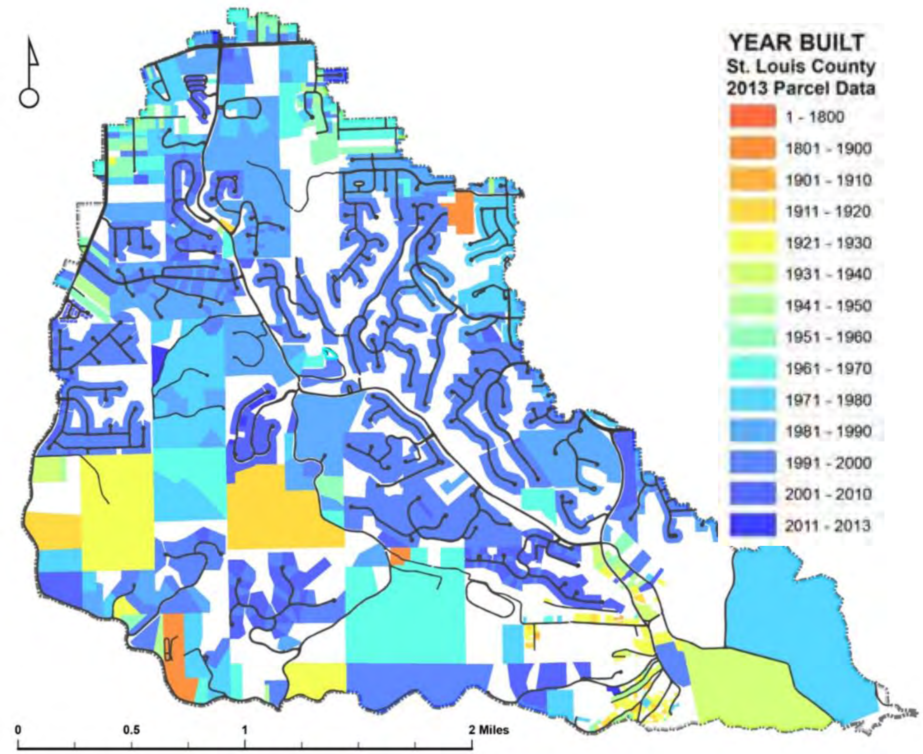
U.S. Department of Agriculture, Natural Resource Conservation Service, *New Jersey Pasture Management Guide for Horse Owners,* (Columbia, MO: 2011), 16-17. (http://www.esc.rutgers.edu/publications/stablemgt /E307.htm)

Early on in our investigation we suspected that septic systems could be a significant source of bacteria, many of the watershed's older homes were built long before the area was reached by centralized sewer infrastructure in the late 80's. Septic systems are a notorious source of bacteria in many small streams and lakes across the country. The EPA estimates that 168,000 viral illnesses and 34,000 bacterial illnesses occur each year as a result of ingestion of improperly treated well water, and malfunctioning septic systems have been identified as one potential source of ground water contamination. The steep Karst topography and rocky soils of the Kiefer Creek Watershed make it especially vulnerable to the negative effects of inadequately designed and maintained septic systems.

The first step in determining the potential bacteria loading from septic systems in the watershed is to quantify the number of septic systems in the watershed. Information on septic systems is usually in the form of an educated estimate based on census data and land use characteristics. A process of elimination was developed that employs datasets and assistance from the Metropolitan St. Louis Sewer District and St. Louis County, which rendered a highly refined septic system dataset for the watershed. This process can and should be employed across the entire county to guide the strategic deployment of improved infrastructure connectivity.

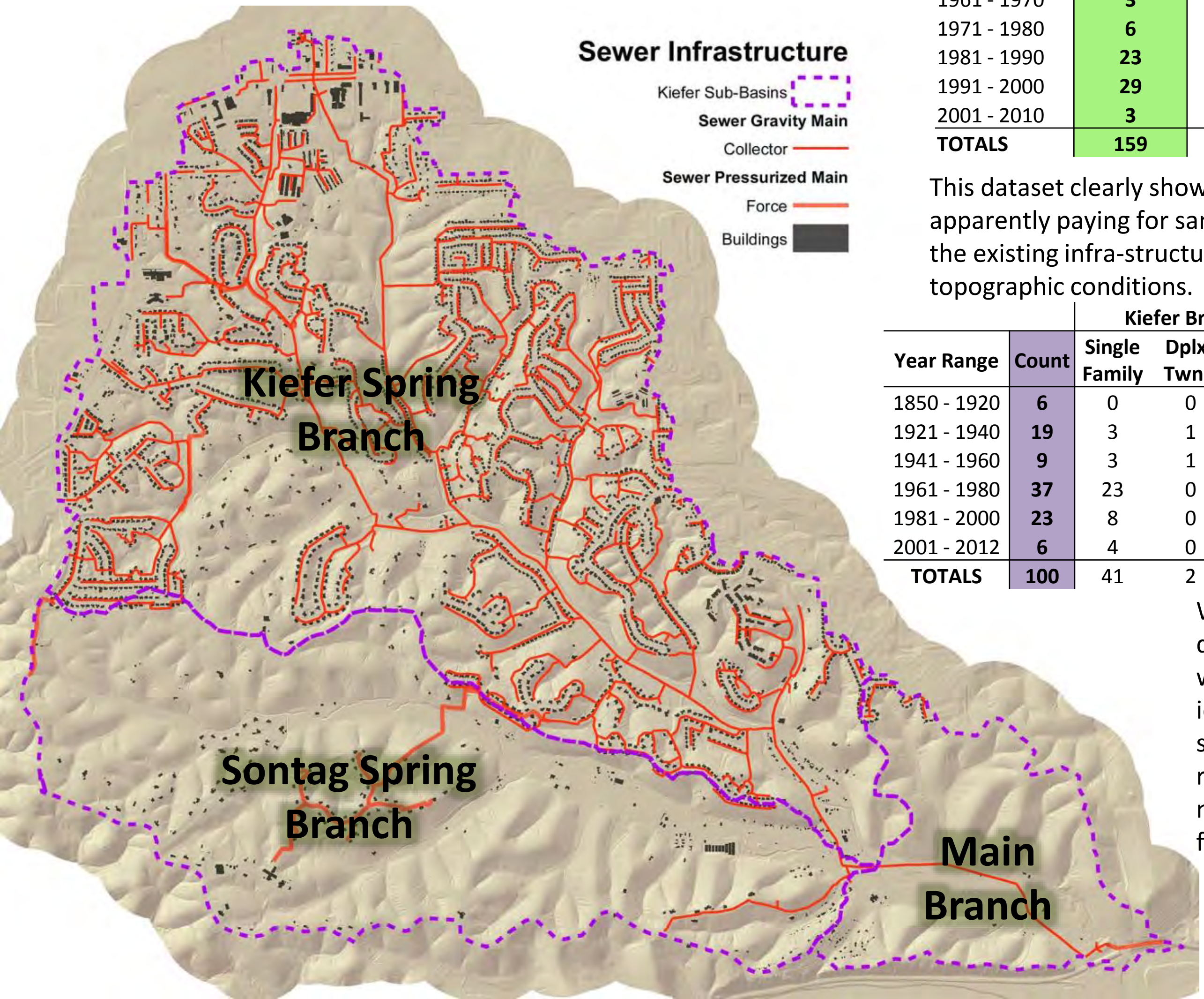
The St. Louis County Parcel Database contains a wide range of useful attribute data including a column called 'YEARBLT,' which refers to the year in which a structure was first built on the according to county records. The MSD pump station in Castlewood State Park came online in 1986, and serves the majority of the parcels within the Kiefer Creek catchment. All non-vacant watershed parcels developed prior to the operational date of the pump station were extracted to a new dataset representing potentially un-sewered parcels based on the infrastructure timeline.

Year Built Range	Non-Vacant Parcels	Single Family	Duplex Townhome	Multi-Family	Institutional & Parks	Commercial & Industrial
1900 >	**3**	3	0	0	0	0
1901 - 1910	**2**	2	0	0	0	0
1911 - 1920	**20**	19	1	0	0	0
1921 - 1930	**62**	58	1	1	1	1
1931 - 1940	**12**	8	1	2	1	0
1941 - 1950	**33**	32	0	0	0	1
1951 - 1960	**64**	58	1	0	2	3
1961 - 1970	**62**	55	1	1	1	4
1971 - 1980	**310**	247	0	53	2	8
1981 - 1985	**180**	140	0	33	1	6
Total	**748**	**622**	**5**	**90**	**8**	**23**



St. Louis County Missouri, GIS Service Center, *Saint Louis County Parcel Dataset,* [DVD-Shapefile] St. Louis County Government, 2014.
U.S. Environmental Protection Agency, Office of Water, Office of Research and Development, Onsite Wastewater Treatment Systems Manual (EPA/625/R-00/008, Washington, DC: GPO, 2002), 1-7, Table 1-3.

The year built analysis was presented to agency and community partners in a watershed planning meeting, in the ensuing discussion asked the sewer district compare their billing records for sanitary sewers to the non-vacant addresses in the watershed. With this approach we were able to identify properties unlikely to be connected to sanitary sewers. However, around the same time, we also requested that the sewer district share with us the geodatabase of sanitary sewer infrastructure in and around the watershed.



Year Range	Count	Kiefer Spring Br. Single Family	Kiefer Spring Br. Institu - tional	Sontags Spring Br. Single Family	Sontags Spring Br. Recrea - tional	Kiefer Creek Single Family	Kiefer Creek Dplx/ TwnH
1900 >	**1**	1	0	0	0	0	0
1901 - 1910	**1**	0	0	1	0	0	0
1911 - 1920	**16**	4	0	4	0	8	0
1921 - 1930	**44**	7	0	13	1	22	1
1931 - 1940	**7**	1	0	6	0	0	0
1941 - 1950	**17**	10	0	1	0	6	0
1951 - 1960	**9**	3	2	0	0	4	0
1961 - 1970	**3**	1	0	2	0	0	0
1971 - 1980	**6**	2	0	1	0	3	0
1981 - 1990	**23**	19	0	4	0	0	0
1991 - 2000	**29**	2	0	27	0	0	0
2001 - 2010	**3**	2	0	1	0	0	0
TOTALS	**159**	52	2	60	1	43	1

This dataset clearly showed that a number of residences, which are apparently paying for sanitary sewers, could not feasibly be connected to the existing infra-structure do to their location relative to sewer lines and topographic conditions.

Year Range	Count	Kiefer Branch Single Family	Kiefer Branch Dplx/ TwnH	Kiefer Branch Commercial	Spring Branch Single Family	Spring Branch Dplx/ TwnH	Spring Branch Commercial	Kiefer Main Branch Single Family	Kiefer Main Branch Dplx/ TwnH	Kiefer Main Branch Multi-Family
1850 - 1920	**6**	0	0	0	5	0	0	1	0	0
1921 - 1940	**19**	3	1	0	10	0	1	1	1	2
1941 - 1960	**9**	3	1	1	3	0	0	1	0	0
1961 - 1980	**37**	23	0	0	12	1	1	0	0	0
1981 - 2000	**23**	8	0	0	15	0	0	0	0	0
2001 - 2012	**6**	4	0	0	2	0	0	0	0	0
TOTALS	**100**	41	2	1	47	1	2	3	1	2

We continue to work with partners to resolve the discrepancy between the two analyses, however we garnered enough information to be able to identify 159 residences that do not pay for sanitary sewers and another 100 non-vacant residential and commercial properties that were not detected as unbilled, but are outside of the feasible reach of the existing infrastructure.

The next step in understanding the potential impact of septic systems in the watershed was to assess the identified parcels based on available data on a range of factors related to septic system function. Each factor has been broken down into a ranking representative the relative significance of each factor attribute, the higher the category and overall ranking, the higher the potential for system failure and bacterial loading.

Some factors are related specifically to the function of the drip field component of a typical septic system. Although it is not possible to use remote sensing to determine the specific location of the drip fields, it is possible to establish a probable drip zone area by creating a simple 300' buffer from the main building on each parcel. This is most pertinent on larger parcels where a wide range of conditions may be present across the entire parcel; a focused analysis area around the main building is necessary to render accurate results.

- Parcel Area: The first factor we considered is the parcel area, without sufficient area for a septic system it is unlikely that the system is effectively eliminating the bacteria in the effluent. The plumbing ordinance for St. Louis County regarding parcel area is as follows:

  22.4.1 Where the premises are served by a public water main, the minimum lot size in which an individual sanitary sewage disposal system may be installed is twenty thousand (20,000') square feet; otherwise, the required lot size on which an individual sanitary sewage disposal system may be installed is thirty thousand (30,000') square feet.

Parcel Area (Square Feet)	Rank	Kiefer Spring Branch	Sontag Spring Branch	Kiefer Main Branch	Total
< 10000	**10**	5	17	11	**33**
10000 – 20000	**9**	13	23	11	**47**
> 20000	**1**	80	95	4	**179**

Assuming that all parcels in the watershed are served by a public water main, there are 80 likely septic systems, or about 31% of the likely systems in the watershed, on parcels that are less than 20,000 square feet, with 33 which are less than 10000 square feet. These systems are likely to be failing due to a lack of sufficient area for processing of effluent to effectively eliminate bacteria. All of these systems are located within 1.25 miles of the swimming area in Castlewood State Park and all but one are on parcels developed before 1980 with an overall average estimated system age of 82 years.

- Septic System Estimated Age: As septic systems age the likelihood of failure increases. Older systems also lack the advantage of modern system design and any system built prior to 1996 was not subject to state design standards. Using the YEARBLT attribute data rankings were assigned from 1 to 10.

System Age (Years)	Rank	Kiefer Spring Branch	Sontag Spring Branch	Kiefer Main Branch	Total
> 50	**10**	38	68	25	**131**
41 - 50	**9**	6	9	0	**15**
31 - 40	**7**	34	12	1	**47**
21 - 30	**5**	12	26	0	**38**
11 - 20	**3**	5	19	0	**24**
1 - 10	**1**	3	1	0	**4**

Assuming that the year built data is indicative of the age of the septic system, there are only 28 systems that were likely to be built in accordance with state design standards. At the same 146 systems are likely to be more than 40 years old. With excellent design and maintenance, including replacement of broken and rusted components, a septic system can function indefinitely. Without information on specific system designs it is difficult to assume a certain rate of failure based on age, for example concrete septic tanks can last indefinitely while metal tanks usually fail due to rust in 15 to 20 years. Drip fields tend to have a lifespan of around 20 years, however this can vary depending on the soils, slope and encroachment of plant root systems. Considering these factors it also very likely that many older systems in the watershed have had failing components replaced at some point, however for this to happen a failure would have to have been detected. In some cases a failing system may not be apparent if the effluent flows directly into the sub-surface flows where it will not be easily detected.

http://www.stlouisco.com/Portals/8/docs/Document%20Library/Public%20Works/code%20enforcement/ordinances/09-UPC-Plumb-Ord.pdf.
http://inspectapedia.com/septic/Septic_System_Life.php

- Land Cover: Overall trees are great for the watershed and perform irreplaceable environmental services while providing habitat, however they can also wreak havoc on a septic system. Some newer septic systems do not require a drip field, however most do, and drip fields work best when the effluent is exposed to the ultra violet rays from sunlight. Tree root systems can also damage the drip field, lateral connection and septic tank. Drip field areas with low amounts of un-forested areas are more likely to malfunction and have been ranked accordingly on a scale of 1 to 10.

Grass Area	Rank	Kiefer Spring Branch	Sontag Spring Branch	Kiefer Main Branch
$10m^2$ >	10	0	2	0
$11m^2$ - $25m^2$	9	0	2	2
$26m^2$ - $50m^2$	8	0	6	3
$51m^2$ - $75m^2$	7	1	6	4
$76m^2$ - $125m^2$	6	4	12	5
$126m^2$ - $175m^2$	5	3	5	3
$176m^2$ - $250m^2$	4	5	9	5
$251m^2$ - $500m^2$	3	19	16	3
$500m^2$ - $1000m^2$	2	14	11	1
$1001m^2$ <	1	52	66	0

- Soils - According to the SSURGO soils database from the USDA there are no soils appropriate for septic systems in the watershed, and generally the typical Ozark soils and karst topography are not well suited for septic systems. That said, it is useful to consider the hydrologic soil groups in terms of their potential to process septic system effluent or transmit it untreated into the stream flow. When a septic system is installed or inspected according to current design guidelines and local ordinance a percolation test is conducted to calibrate the system design, especially the drip field, to the soil conditions on site.

Hydrologic Soil Group	Rank	Kiefer Spring Branch	Sontag Spring Branch	Kiefer Main Branch
D	10	6	11	0
C	7	57	84	16
B	3	35	40	10

https://engineering.purdue.edu/mapserve/LTHIA7/documentation/hsg.html

- Slope: The steeper the slope of a septic system drip field the less likely that effluent will be fully treated before it runs off the site and into the nearest stream channel. The average slope of each potential drip field zone has been calculated to assign a ranking from 1 to 10.

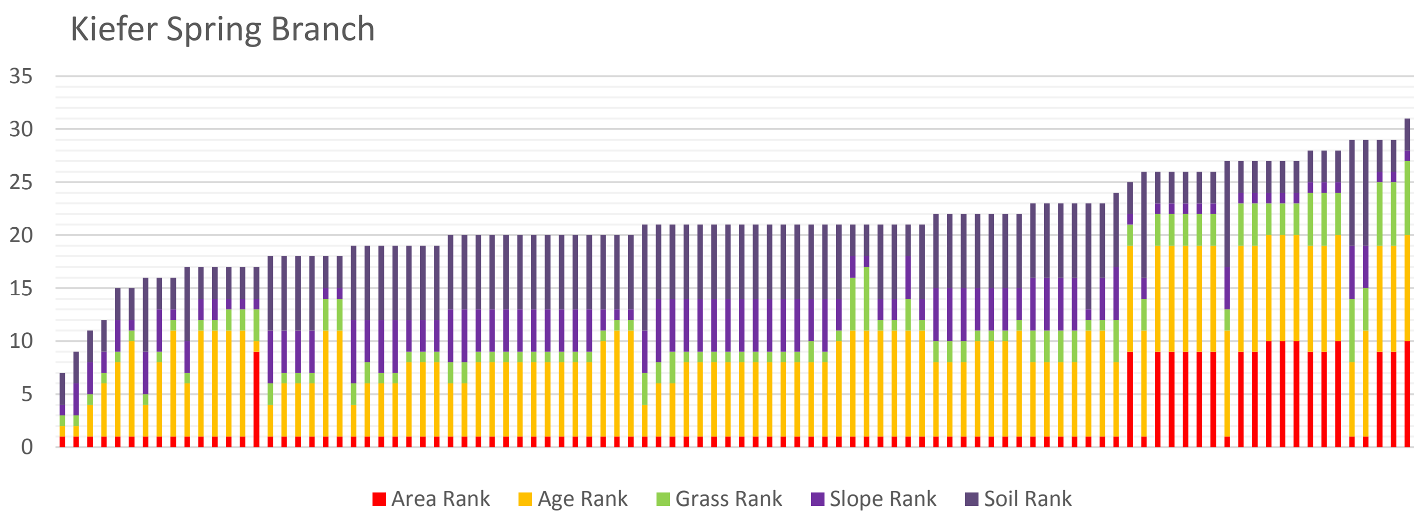
Average Slope (%)	Rank	Kiefer Spring Branch	Sontag Spring Branch	Kiefer Main Branch
9.01 -10	10	0	1	0
8.01 - 9	9	0	0	0
7.01 - 8	8	0	1	0
6.01 - 7	7	0	6	0
5.01 - 6	6	2	17	1
4.01 - 5	5	25	22	12
3.01 - 4	4	24	30	10
2.01 - 3	3	9	24	2
1.01 - 2	2	9	19	0
0.0 - 1	1	29	15	1

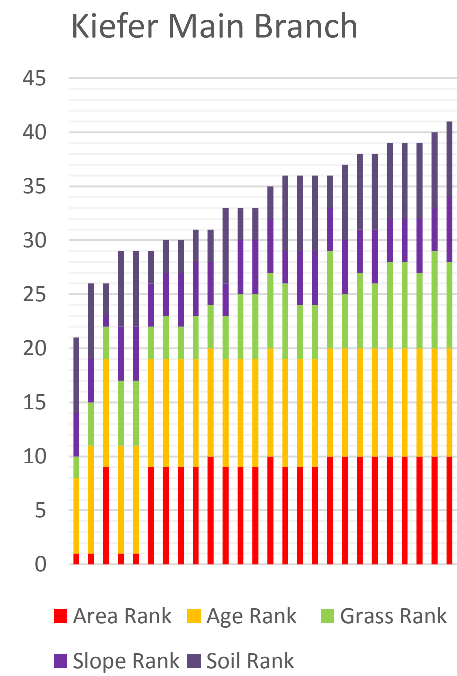
Each attribute ranking has been added up for each parcel with a septic system to create an overall ranking of system in the watershed with a maximum possible raw score of 50 and a minimum raw score of 5.

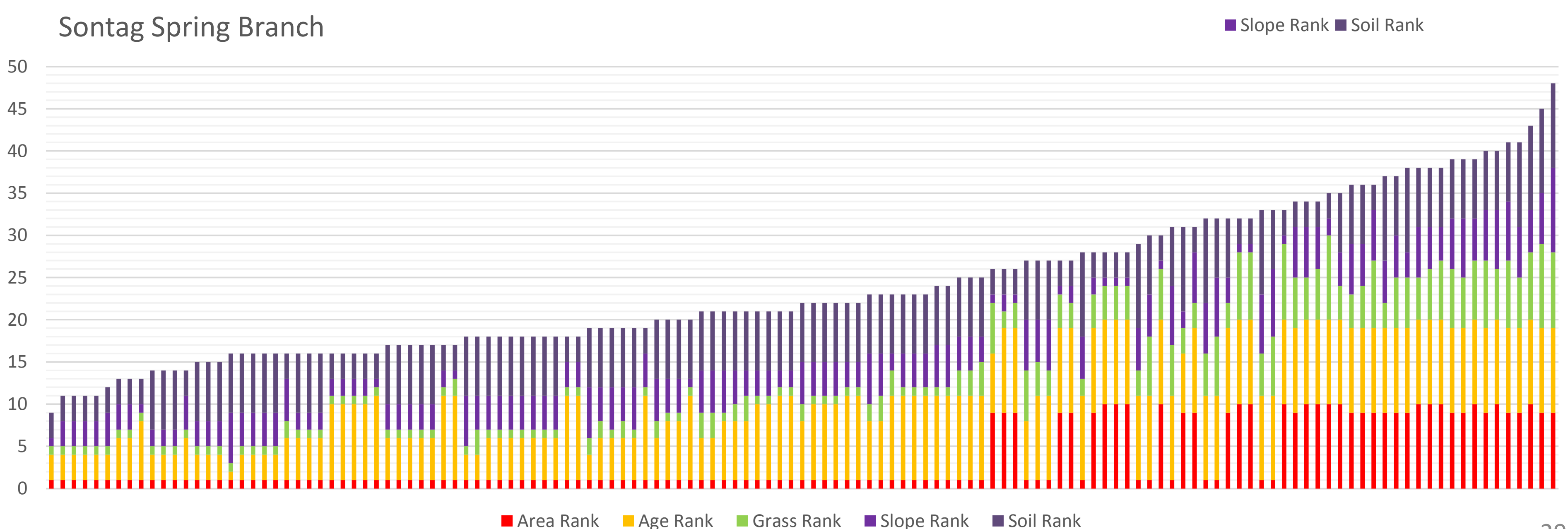
Raw Score	Kiefer Spring Branch	Sontag Spring Branch	Kiefer Main Branch	Total
46 to 50	0	1	0	1
41 to 45	0	4	1	5
36 to 40	0	14	11	25
31 to 35	1	16	6	23
26 to 30	19	16	7	42
21 to 25	36	26	1	63
16 to 20	36	42	0	78
11 to 15	4	15	0	19
5 to 10	2	1	0	3

This raw score provides a good overview the conditions that effect each system in the watershed, however certain conditions are more consequential to the function of a system than others. Parcel area, age and grass area are all critical aspects of septic system function, while slope and soil group are less pertinent in this analysis. The following graph helps us better understand the septic situation in the watershed.

Estimating the failure rate of septic systems is imprecise, only through a professional inspection can a system be conclusively evaluated. However, at this point inspection reports are not necessarily submitted to or collected by any regulatory agency, making it necessary to use estimates such as these to evaluate the potential impacts from failing systems when developing a watershed plan.







We used established research on the coliform density and daily waste output from each non-point source we delineated in the watershed to quantify to total load from each source. Our calculations were calibrated based on relevant characteristics and attributes that impact the likelihood that the non-point source bacteria will reach the stream.

Through interviews with horse owners in the watershed, we learned that on average local horses are outside 70% of the time, where manure is not typically cleaned up. We were also able to determine that about 10% of the manure in the watershed is stored outdoors in uncovered piles. Horses produce a high volume of waste that has a low density of bacteria, the small population of horses in the watershed should not pose a significant threat to water quality, especially with improved storage and composting of horse manure and effective pasture management. Even if the horse manure is uncovered and located close to a tributary channel, it could contribute only a relatively small amount of bacteria compared to septic systems.

Bacterial output from dogs was assumed to be entirely outdoors with a 50% likelihood of cleanup before a rain event could wash the waste into the stream. Outdoor cats are likely to defecate outdoors 100% of the time, but only about 55% of cats in the US have outdoor access. Dogs have been found to contribute up to 15% of the bacteria in local watersheds that have a higher population density, and subsequently more pets, than the Kiefer Creek Watershed. These highly pet populated watersheds display lower concentrations of bacteria than Kiefer Creek, and so it is unlikely that waste from domestic pets is the primary bacteria source in Kiefer Creek. It has also been found that desiccation of animal and wildlife waste typically results in 90% die off of bacteria.

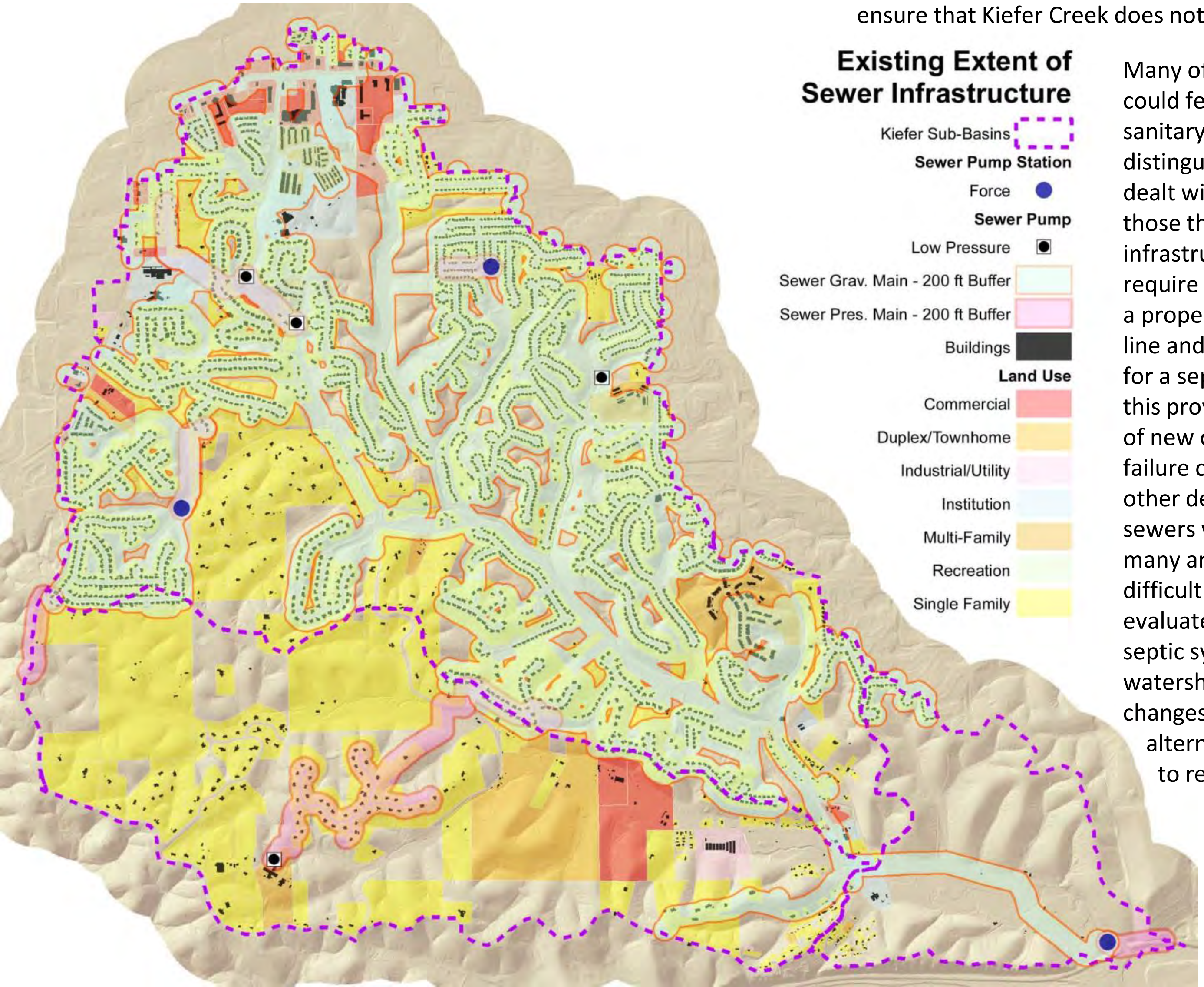
Failing septic systems can produce a very high concentration of bacteria that is highly mobile, untreated wastewater from leach fields can also build up in shallow soils to be washed into the nearby stream by rainfall. According to the EPA the estimated failure rate of septic systems in Missouri is 30% to 50%, with old age and poor design being major factors responsible for system failure. Using our attribute analysis we have assumed that all systems with an age, parcel area or grass area rank of 9 or 10 are likely to be failing. The following table uses scientifically established bacteria output rates to estimate the overall bacteria loading to Kiefer Creek.

Estimated Loading of Non-Point Sources of Bacteria in the Kiefer Creek Watershed

Non-Point Source	Fecal CFU Density (MPN/g)	Fecal Output (g/day)	Bacteria Output Per Unit/Per Day	Raw NPS Units	Unit Calibration	Total NPS Units	Total Daily CFU Output	Bacteria Die Off Rate	% NPS Loading	Daily Bacteria Output	% of Total Bacteria Load
Kiefer Spring Branch Failing Systems	4.66E+008	150	6.99E+010	45 Systems	Est. Total People Using Septic Systems based on 2010 census data, building use and/or residential square feet	109	7.62E+012	None	100%	7.62E+012	29.82%
Sontag Spring Branch Failing Systems	4.66E+008	150	6.99E+010	79 Systems		200	1.40E+013	None	100%	1.40E+013	54.72%
Kiefer Main Branch Failing Systems	4.66E+008	150	6.99E+010	25 Systems		52	3.63E+012	None	100%	3.63E+012	14.23%
Dogs	4.11E+006	450	1.85E+009	2472 Dogs	50% Cleanup	1236	2.29E+012	90% Die Off	10%	2.29E+011	0.89%
Cats	1.49E+007	20	2.98E+008	2700 Cats	55% Outdoors	1485	4.43E+011	90% Die Off	10%	4.43E+010	0.17%
Horses (Pasture)	1.81E+005	23182	4.20E+009	116 Horses	85% Outdoors	98.6	4.14E+011	90% Die Off	10%	4.14E+010	0.16%

U.S. EPA, Office of Water, Office of Research and Development, Onsite Wastewater Treatment Systems Manual (EPA/625/R-00/008, Washington, DC: GPO, 2002), 1-7, Table 1-3.
Scott R. Loss, Tom Will and Peter P. Marra,"The impact of free-ranging domestic cats on wildlife of the United States," *Nature Communications 4:1396* (2013) DOI: 10.1038/ncomms2380.
Douglas L. Moyer and Kenneth E. Hyer, U.S. Department of the Interior, U.S. Geological Survey, *Use of the Hydrological Simulation Program–FORTRAN and Bacterial Source Tracking for Development of the Fecal Coliform Total Maximum Daily Load (TMDL) for Blacks Run, Rockingham County, Virginia*, Water-Resources Investigations Report 03-4161 (Richmond, VA: 2003), 26-34.

Not only do septic systems make up the majority of the excess bacteria in Kiefer Creek, they are also the most complex and expensive source of bacteria to control. In the Kiefer Creek Watershed a major investment has been made to install approximately 60 miles of sewer lines, 3000+ lateral connections and seven pumping facilities to ensure that the human waste generated in the watershed does not wind up polluting the creek. Unfortunately it only takes a relatively small number of failing septic systems to render the stream unsafe for recreation, undermining the efforts to protect water quality with centralized sewers. It may seem expensive to expand sewer access and connect homes currently on septic systems to sewers, but this cost is tiny compared to the costs paid by the majority of watershed residents to have sewers to ensure that Kiefer Creek does not become polluted with human waste.



Many of the homes likely to have septic systems could feasibly be connected to the existing sanitary sewer infrastructure. It is important to distinguish which systems may be most easily dealt with through a lateral connection, from those that will require an expansion of infrastructure. Both MSD and St. Louis County require that a lateral connection be made when a property boundary is within 200' of a sewer line and where there is inadequate parcel area for a septic system. However, it appears that this provision is primarily implemented in cases of new construction and when a septic system failure complaint is filed. With many homes and other developments that were built before sewers were available in the watershed, and many areas still lacking access, Kiefer faces a difficult predicament. In the next section we evaluate the current connective potential of septic systems to sewer infrastructure in the watershed, then investigate the potential policy changes, infrastructure expansion and alternative approaches that will be necessary to reign in the bacteria in Kiefer Creek.

In the Kiefer Creek Watershed there are cases where a property line may be within 200’, but a connection is not feasible due to elevation or relative distance from the main building on larger parcels. In this analysis septic parcels have been divided into four categories: systems that can be connected; systems that are within 200’ but cannot be connected due to elevation; systems that are within 200’ but would require more than 500’ to connect via lateral; and systems that are not within 200’.

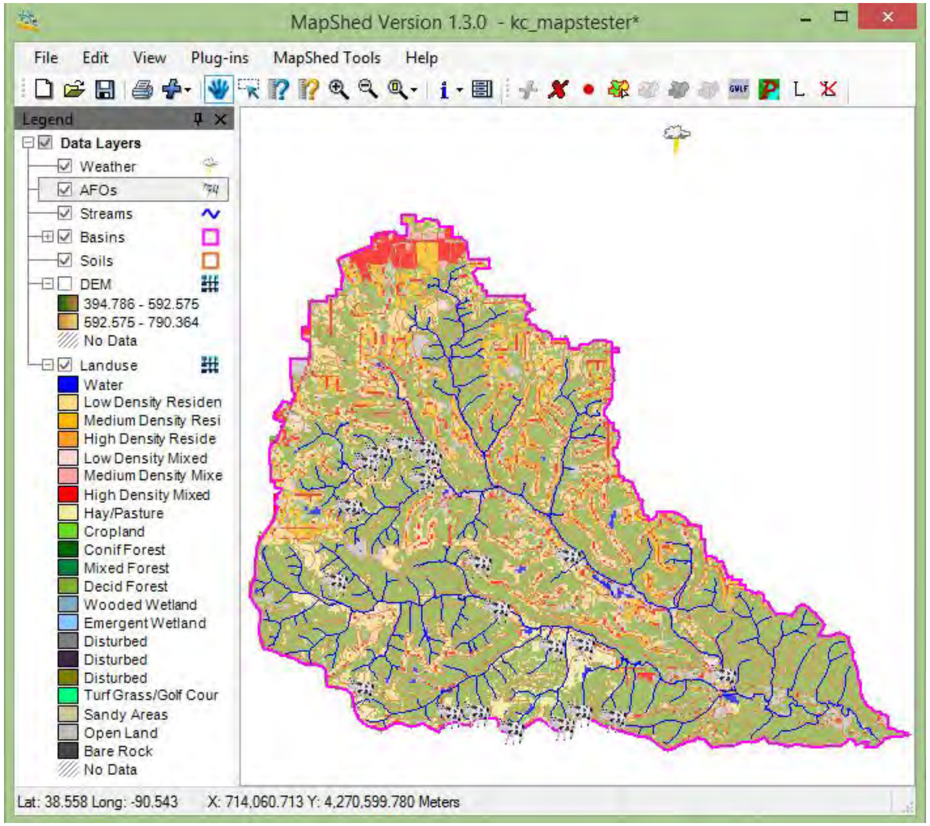
Lateral Connectivity Category	Kiefer Spring Branch	Sontag Spring Branch	Kiefer Main Branch
Connectable (Connect) Parcel Distance < 200ft Building Distance < 500ft Building Elev. > Sewer Elev.	47	4	1
Difficult Connection (D_Connect) *Building Distance > 500ft* Parcel Distance < 200ft Building Elev. > Near Sewer Elev.	2	1	0
Elevation Conflict (No_Connect_E) *Building Elev.<Near Sewer Elev* *Distance to Lower Sewer Elev.>500ft.* Parcel Distance < 200ft	1	20	0
Distance Impediment (No_Connect_PD) *Parcel Distance > 200ft* *Distance to Lower Sewer Elev.>500ft.*	48	110	25

***** This is only an estimate, an engineering study or inventory of septic systems will be needed to determine actual lateral connectivity.

Watershed Model

Although our first estimate clearly indicates that the majority of the bacteria loading in Kiefer Creek comes from septic systems, we decided to use a watershed model to take more variables into account and run a variety of scenarios based on probable and improved conditions in the watershed. We also used this model to estimate the bacteria load reduction from the implementation of best practices that would reduce the number of failing septic systems in the watershed. The watershed model that we selected for this analysis is called MapShed and it was developed by the University of Pennsylvania Department of Earth Sciences. MapShed is a system that utilizes a combination of GIS datasets, weather data, and a wide range of input settings to simulate the production and transport of pollutants in a watershed. One major strengths of this model is the ability to directly quantify the number of septic systems in a basin, then derive monthly bacteria production and loading averages by source. Within this model other sources of bacteria that are considered are farm animals, urban runoff, and wildlife. By assembling our collected data on Kiefer Creek into layers and inputs for the model we have been able to better understand the loading reductions necessary to bring Kiefer Creek into compliance with the recreational use bacteria standard.

The foundation of the MapShed model is built on the GWLF (Generalized Watershed Loading Function) framework, but goes further to provide a GIS based interface that utilizes geospatial data and numeric input settings to create a comprehensive input file for the GWLF-E model.



To construct the watershed model we first had to convert our extensive GIS data into the following layers and datasets that could be understood by the model. It is clear that this model, like virtually every other watershed model, is designed for typical use in larger basins than Kiefer Creek. MapShed, and the GWLF model it is built upon, are geared towards modeling agricultural nutrient loading, but bacteria is also a prominent component of the loading analysis. By understanding the way the model works, we have been able to create datasets that provide an accurate enough representation of the conditions in Kiefer Creek to elucidate the bacteria loading pattern in the watershed.

DEM – A Digital Elevation Model is a raster (pixel based) dataset that describes the terrain of the watershed. This dataset is used by the model to determine where and how fast water collects and transports pollution. Although through the use of LiDAR we have been able to create incredibly high precision elevation models of the ground and the forest height, the MapShed model is optimized to use a DEM with a resolution around 20 meters, so we used the aggregate function in ArcGIS to produce an optimal DEM for the model. A higher resolution (up to 10m) DEM can be used but the variability in the results related to bacteria would likely be minimal.

LULC – Land Use and Land Cover is a raster based dataset that describes the composition of the surface of the watershed. The GWLF model uses this layer to determine typical pollutant loading and runoff coefficients based on 16 categories of land use. Mapshed accepts 21 total categories, but GWLF considers some to be the same in terms of model variables e.g. deciduous, mixed, and coniferous forests.

Water	Turf/Golf	Low-Density Residential
Hay/Pasture	Open Land	Medium-Density Residential
Cropland	Bare Rock	High-Density Residential
Forest	Sandy Area	Low-Density Mixed Urban
Wetland	Disturbed	Medium-Density Mixed Urban
		High-Density Mixed Urban

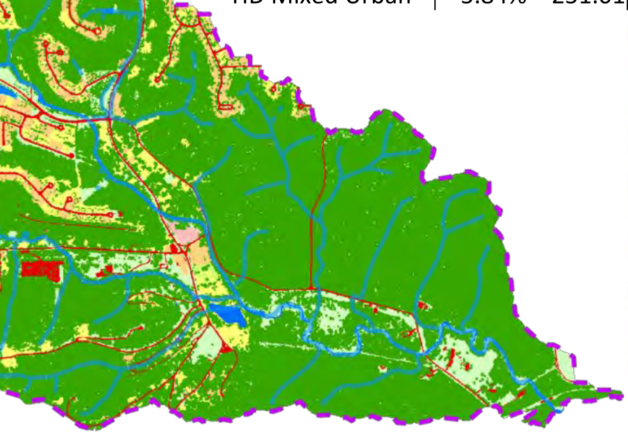
The geospatial data that we have collected from Kiefer Creek is of a higher resolution than is optimal for the model which is designed to use a LULC layer with a resolution no higher than 20 meters. This layer plays a key role in calculating the bacteria loading from wildlife and urban areas, which includes typical loading from pet ownership as a component of residential and urban land use. This layer combines data from the St. Louis County Parcel dataset, MSD impervious surface dataset, and the MSD LiDAR derived forest cover dataset. There are six categories of residential and commercial land uses which are based on the percentage of impervious surface area:

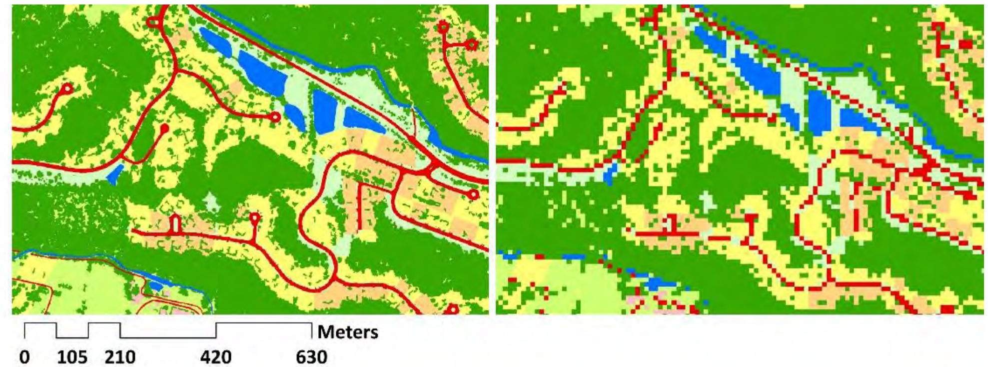
- Low Density Residential/Mixed Urban = < 30% Impervious
- Medium Density Residential/Mixed Urban = 30% - 75% Impervious
- High Density Residential/Mixed Urban = >75% Impervious

First, we used the impervious surface data from MSD and the parcel data from St. Louis County to calculate the percentage of impervious surfaces on all commercial and residential properties (industrial and institutional uses were included as commercial). Starting with a blank raster created from the watershed boundary, we assigned the appropriate MapShed residential and commercial land use values to the raster. Then we assigned the high-density mixed land use to roads in the watershed. There isn't a proper category for roads, however they are in essence 100% impervious and are a significant source of non-point source pollutants including bacteria.Before adding the forests, we assigned the areas of the watershed that were not impervious, residential or commercial with the category of open space. Used as a default value, it represents non-forested areas that are also not developed or impervious surfaces. This initially included significant areas of parkland, vacant parcels and common ground in the watershed. Then we used our LiDAR based forest cover data to define the forest cover across the entire watershed, including areas previously defined as any other land cover type. The last step in shaping the land use layer was to add in pastures where horses are kept in the watershed, we selected the parcels with horses and changed any open space areas into pastures.

We then used the aggregate function in ArcGIS to reduce the resolution of the LULC raster from 1m to 20m for optimal processing in Mapshed. In the GWLF model the variables related to land use are summarized for each drainage area analysis performed, so it was only important to ensure that when the aggregate function was used the land use categories maintained the same area of coverage from the high resolution raster to the low resolution raster.

We compared the results of the aggregated function to the original 1m resolution LULC layer and found the greatest variation in percent coverage by category to be 0.54% in the water category. This difference more than doubles the water area from 19.13 acres to 42.25 acres, and could have a slight impact on the model, although at less than one percent of watershed the impact will be very small. Water is also the only land use that changes on a regular basis depending on the amount of rainfall, evaporation, flooding and temporary impoundments built by beavers.



Category	20m%	Acres	1m %	Acres	% Δ	Acres Δ
Water	0.99%	42.45	0.45%	19.13	0.54%	23.32
Forest	64.17%	2758.02	64.54%	2773.77	-0.37%	-15.75
Open Land	6.19%	266.21	6.20%	266.39	0.00%	-0.18
Hay/Pasture	3.72%	159.94	3.72%	160.03	0.00%	-0.09
LD Residential	12.69%	545.48	12.83%	551.22	-0.13%	-5.73
MD Residential	5.84%	250.79	5.84%	250.83	0.00%	-0.04
HD Residential	0.01%	0.52	0.01%	0.52	0.00%	0.00
LD Mixed Urban	0.30%	12.90	0.34%	14.42	-0.04%	-1.52
MD Mixed Urban	0.25%	10.68	0.25%	10.68	0.00%	0.00
HD Mixed Urban	5.84%	251.01	5.84%	251.01	0.00%	0.00

Soils – The soils layer is critical to the GMLF model and it requires three specific soil attributes; AWC (available water-holding capacity), KF (soil erodability (K) factor) and dominant hydrologic soil group. Using the USDA SSURGO soils database to collect the soil data, we found that the AWC and KF categories were not complete throughout the watershed, so we interpolated these values based on the soil types and formations.

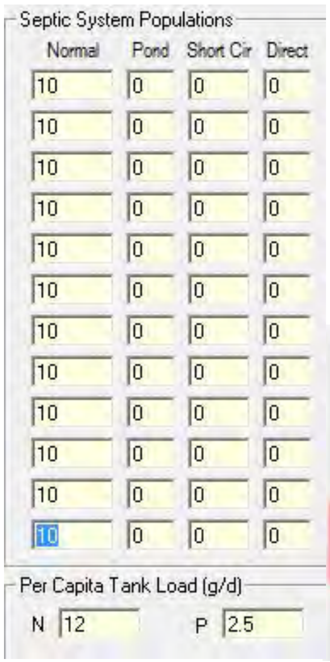
AFO – Using the Animal Feeding Operation layer we were able to include the number and location of horses in the Kiefer Creek Watershed, which are used in bacteria and nutrient loading equations.

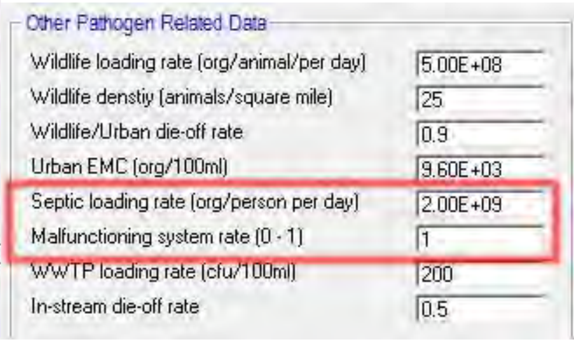
Weather – To utilized the GWLF modeling routine through MapShed we had to upload four years of weather data from at least two weather stations. This data had to include daily precipitation, minimum temperature and maximum temperature. We located two precipitation data collection sites close to the watershed using the CoCoRaHS (Community Collaborative Rain, Hail & Snow Network) website, which had data for 2013 and 2014. For 2011 and 2012 precipitation data and temperature data we used the National Weather Service's NOWData - NOAA Online Weather Data search tool. The NOWData tool provided us with information for the St. Louis Area, which was used to fill in precipitation data for 2011 and 2012 and temperature data for all four years. The data we have included represents the normal range of weather in the St. Louis Region and so it is representative of the expected range of conditions in the watershed. The model will produce bacteria loading data in terms of monthly loading. Unfortunately we will not be able to look up bacteria loading from a specific date, so the watershed specific precision of the weather data is not critical.

Streams – The streams layer helps the model determine how pollutants move through the watershed and calculate erosion rates. We used the MSD stormwater channel dataset, which was modified slightly to create complete connectivity between stream segments.

Basins – The basins layer is used to establish the boundaries of the GWLF-E analysis, by looking at sub-basins the model can provide valuable comparisons and insights into target areas. We used two different basins layers for our analysis, one with the Kiefer Spring Branch and Sontag Spring Branch sub-basins, and one of the entire watershed. This allowed us to look at each major catchment and the overall watershed in terms of bacteria loading by source. Many septic systems are located in the Kiefer Main Branch sub-basin, and they are represented in the difference between the contributions of the Kiefer Spring and Sontag Spring Branch and the overall watershed.

Septic Systems – In the Mapshed model we developed 12 scenarios to help us understand the potential range of bacteria loading in the Kiefer Creek Watershed. Each scenario controls for all factors except for the number of people on failing septic systems, allowing us to target our evaluation on the changes we can expect with improved sewerage in the watershed. In the model we used two input parameters to express the septic system output in the watershed, under the Nutrient Data settings menu we were able to assign the number of systems in the watershed, and under the Animal Data settings menu we are able to assign the rate of failure as a decimal expressing the percent of failing systems. When testing the model we found that the type of septic system did not impact the outcome of the model, but that the percent failure rate directly effects the loading from septic systems. For our purposes we set the failure rate to 1 (100%) and just modified the number of people on septic systems to reflect the estimated failure rate within the geography of each modelling scenario. The 'Septic Systems Populations' settings menu is broken down into 12 months in which you can set the septic systems population, which we set to the same population for every month per the scenario conditions. In the 'Other Pathogen Related Data' settings menu we set the malfunctioning system rate to 1. In this menu we can also review and change pathogen loading settings from wildlife and urban areas.





We designed the analysis to present current and improved non-point source bacteria loading from failing septic systems. Each scenario uses our septic system assessment and connectivity analyses to define the failing systems within the scenario conditions based on the systems with the least favorable conditions. Based on the USEPA estimate that 30-50% of septic systems are failing in Missouri, we used 50% as the highest rate of failure among existing systems and 30% as the lowest rate of failure. We also used the identification method, MSD billing data or our infrastructure analysis as a variable in the estimated number of failing systems in the watershed, so all of the scenarios with a '2' only look at the systems identified by MSD. This assumes that the maps of lateral infrastructure are not as up-to-date at the billing records, reducing the total pool of systems to 159.

Scenario A - Assumes that all systems detected exist and that overall they have the highest estimated rate of failure (50%).
Scenario A2 - Assumes that only systems detected by MSD billing records exist and that overall they have the highest estimated rate of failure (50%).
Scenario B - Assumes that all systems detected exist and that overall they have the lowest estimated rate of failure (30%).
Scenario B2 - Assumes that only systems detected by MSD billing records exist and that overall they have the lowest estimated rate of failure (30%).
Scenario C - Assumes that all systems detected exist and that overall they have the highest estimated rate of failure (50%). However, the 32 potentially failing systems that could feasibly be connected to sewers, are connected in this model.

Septic Loading Scenarios		**% Failing**	**# Sep. Sys.**	**Total Septic Pop.**	**MSD ID - Septic Population**			**Infra. ID - Septic Population**		
					Kiefer Total	Kiefer Spring	Sontag Spring	Kiefer Total	Kiefer Spring	Sontag Spring
Scenario A	Potential Existing Conditions	50%	130	**313**	224	67	115	89	25	54
Scenario A2		50%	80	**186**	186	98	50	MSD Systems Only		
Scenario B		30%	78	**178**	142	30	74	36	4	24
Scenario B2		30%	47	**104**	104	10	56	MSD Systems Only		
Scenario C	Failing systems connected to sewers where possible	50%	98	**237**	176	24	110	61	4	51
Scenario C2		50%	65	**153**	153	17	98	MSD Systems Only		
Scenario D		30%	63	**146**	118	6	74	28	0	24
Scenario D2		30%	42	**94**	94	0	56	MSD Systems Only		
Scenario E	Sewer Expansion*	50%	14	**38**	10	3	7	28	4	24
Scenario E2		50%	1	**2**	2	0	2	0	0	0
Scenario G	Low Fail Rate for Modeling	50%	9	**19**	19	7	6	Failing Systems estimated to depict loading curve		
Scenario G1		50%	4	**10**	10	4	3			

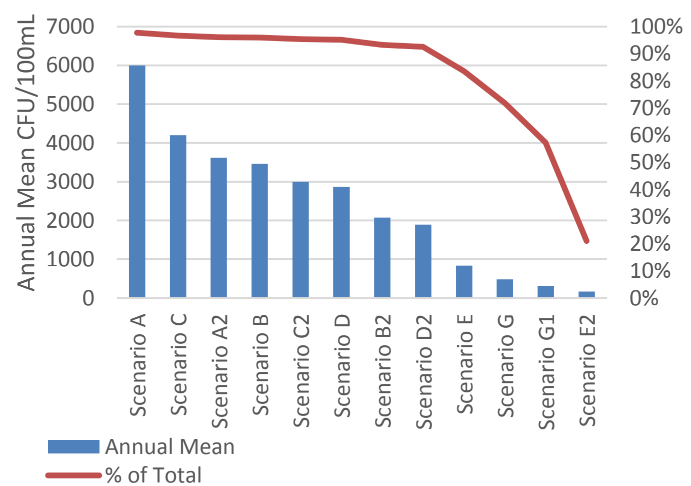
Scenario D - Assumes that all systems detected exist and that overall they have the lowest estimated rate of failure (30%). The 15 potentially failing systems that could feasibly be connected to sewers are connected in this model.
Scenario D2 - Assumes that only systems detected by MSD billing records exist and that overall they have the lowest estimated rate of failure (30%). The 5 potentially failing systems that could feasibly be connected to sewers are connected in this model.
Scenario E - Assumes that all systems detected exist and that overall they have the highest estimated rate of failure (50%). The 32 potentially failing systems that could feasibly be connected to sewers, are connected in this model. Sewers have been extended to reach all of the systems within a 0.75 miles radius around the confluence of the Kiefer and Sontag Spring branches and it is assumed that the systems have connected.
Scenario E2 - Assumes that only systems detected by MSD billing records exist and that overall they have the highest estimated rate of failure (50%). However the 15 potentially failing systems that could feasibly be connected to sewers are connected in this model. Sewers have been extended to reach all of the systems within a 0.75 miles radius around the confluence of the Kiefer and Sontag Spring branches and it is assumed that the systems have connected.
Scenarios G and G1 – We used these scenarios to fill in the gap in the modelling conditions between 2 and 38 people on failing systems. This set was developed in response to modeling results from the first ten scenarios. There is a significant difference between the loading from 38 people on failing septic systems and two people on failing septic systems, we wanted to map out this decline with greater detail than the scenario conditions.

Scenario E Kiefer Total Month	Farm Animals	Septic Systems	Urban Areas	Wildlife	Total	Stream Flow (m^3)	Mean Concentration (cfu/100ml)
Jan	4.52E+10	1.18E+12	8.49E+10	8.40E+10	1.39E+12	1.55E+05	897.1
Feb	5.51E+10	1.07E+12	9.14E+10	7.66E+10	1.30E+12	1.63E+05	793.5
Mar	1.00E+11	1.18E+12	1.13E+10	8.40E+10	1.37E+12	3.50E+05	392.2
Apr	1.33E+11	1.14E+12	1.37E+11	8.13E+10	1.49E+12	9.34E+05	159.6
May	1.06E+11	1.18E+12	1.68E+10	8.40E+10	1.38E+12	7.62E+05	181.8
Jun	1.24E+11	1.14E+12	1.23E+11	8.13E+10	1.47E+12	5.54E+05	264.8
Jul	5.75E+10	1.18E+12	4.20E+09	8.40E+10	1.32E+12	1.66E+05	799.6
Aug	6.93E+10	1.18E+12	2.32E+10	8.40E+10	1.35E+12	6.64E+04	2039.2
Sep	1.67E+11	1.14E+12	6.34E+10	8.13E+10	1.45E+12	1.40E+05	1034.7
Oct	9.62E+10	1.18E+12	5.17E+10	8.40E+10	1.41E+12	1.03E+05	1366.7
Nov	5.62E+10	1.14E+12	5.07E+10	8.13E+10	1.33E+12	9.09E+04	1460.6
Dec	4.59E+10	1.18E+12	2.28E+10	8.40E+10	1.33E+12	1.88E+05	709.4
Total	1.05E+12	1.39E+13	6.81E+11	9.90E+11	1.66E+13	3.67E+06	841.6
% of Total	6.4%	83.6%	4.1%	6.0%			

We ran each scenario for the Kiefer Spring Branch, the Sontag Spring Branch and the total watershed. The models output spreadsheets that contain the results of the GWLF-E model based on the GIS data and input settings. Within the results we are provided with a table showing the pathogen loading in the watershed by source by month.

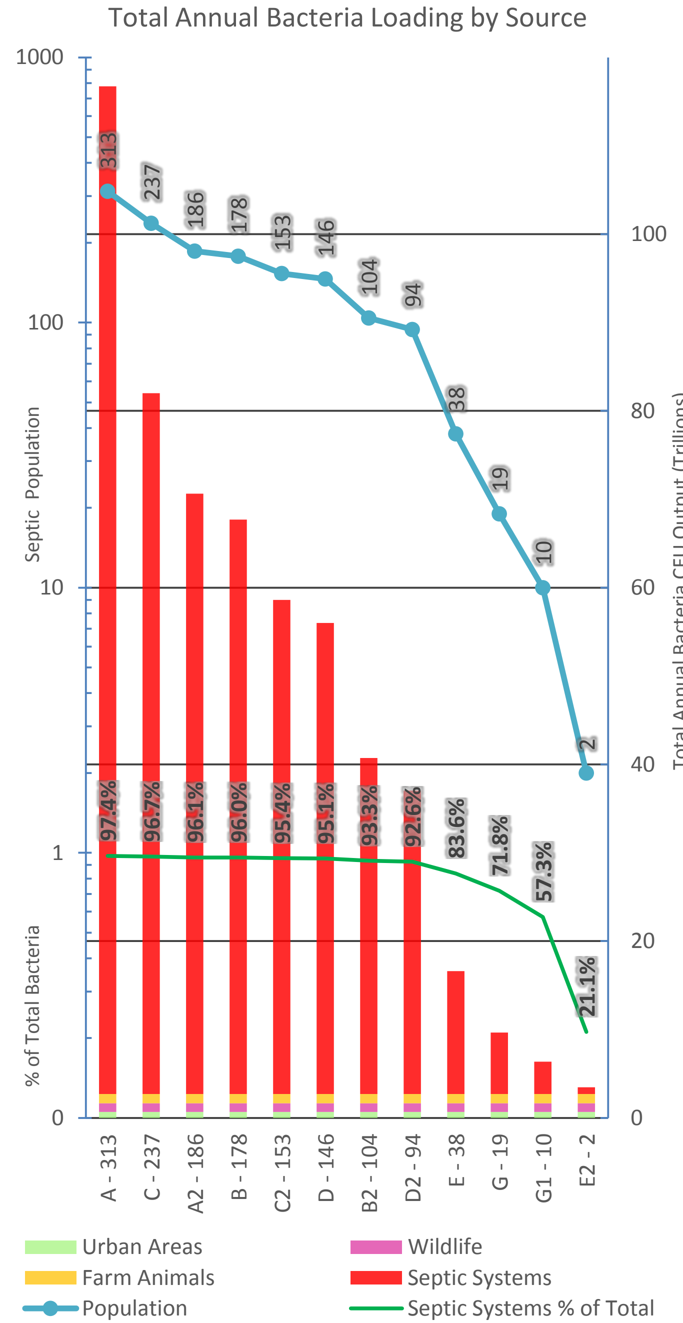
Unfortunately this model does not provide daily loading estimates that could be checked against monitoring data directly, but the data that is provided provides a clear picture of the portion of the bacteria loading from septic systems when compared to that of all other sources combined. It is also worth noting that this model shows increased concentrations of bacteria when there are lower predicted flows based on precipitation data. This makes sense based on the idea that over the course of a month the bacteria produced will be essentially the same and will be constantly discharging, but the amount of water it is diluted by increases with precipitation. This seems to contradict our findings in the correlation between the rainfall and elevated bacteria levels, but that is because the model is looking at a monthly average and also because it cannot capture the complex transport and storage processes occurring in the watershed. The model assumes that the bacteria is transported directly from the septic system into a flowing stream channel, however in many cases in the Kiefer Creek Watershed this may not be accurate. The geology and Karst topography of Kiefer Creek could allow for subsurface areas and losing stream segments to accumulate septic effluent that is stuck until rainfall pushes it through subsurface soils and the groundwater system and into the stream channel.

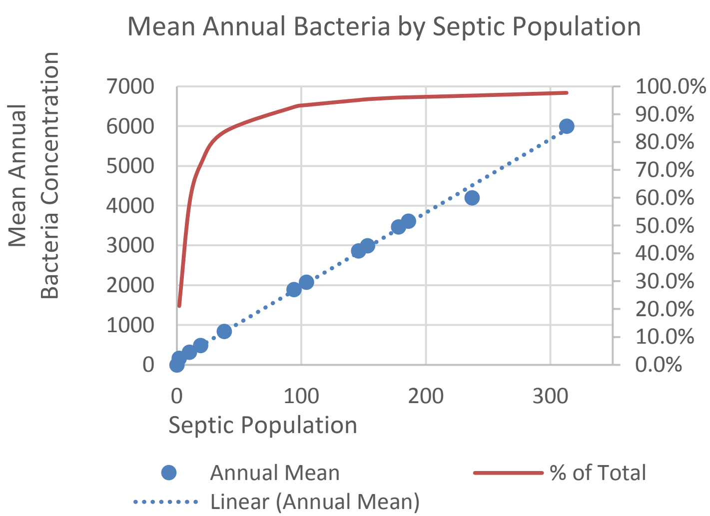
In looking at the water quality monitoring data it is as if Kiefer Creek flushes like a toilet when it rains, leading to the hypothesis that bacteria must build up, to a point, between rain events. When we think in terms of the bacteria building up, or at least being latent between rain events we come back to the point of determining which source of bacteria is contributing the greatest amount to the bacteria in the watershed. It could be that the bacteria doesn't build up very much, there is just a lot of it present an able to quickly move into the stream channel when it rains. Either way the majority source of the bacteria is the key consideration in seeking to reduce bacteria loading and achieve the recreational use water quality goal. Even a relatively small number of failing systems far exceed the loading from other sources.



In this graph we see the annual mean concentration of bacteria by scenario, along with the percent of the total bacteria load from septic systems.

In the graph to the right we can see the total bacteria load from all sources, the population on septic systems and the percent of the total bacteria load by scenario. Along the left y-axis we have plotted the population and percent of total bacteria from septic systems, the axis is in logarithmic scale. Following the right y-axis we have plotted the total annual bacteria output by source in trillions of organisms. The scenarios have been arranged according to the population on septic systems. This graph shows that without reductions in the number of failing systems, it will be impossible to achieve significant reductions in bacteria loading in Kiefer Creek. It is possible that the number of failing systems could be reduced by replacing broken components or entire systems, however this approach has a number of weaknesses. Replacing entire systems can be very expensive, especially on small lots where it may not even be permissible according to current plumbing code regulations regarding lot size. All septic systems, and especially newer systems, require attentive maintenance and will inevitably face component failure at some point. Homeowners may not be able to determine when a system failure is occurring. Kiefer Creek has exactly the wrong kind of geology and hydrology for a proper septic system, and failing systems can discharge into the shallow groundwater, evading detection. By connecting to centralized sewers or adopting an alternative technology like a composting toilet, the bacteria discharge from that population is reduced to zero, there is the potential for sanitary sewer system to break on occasion, but MSD is responsive and adept when it comes to detecting and repairing sanitary sewer issues. Composting toilets require more interaction than most people may be comfortable with; but the cost, reliability and low-impact of this type of system may appeal to people farther from the beaten path in places harder to reach with sewer lines.





In the graph to the left we have plotted the Mean Annual Bacteria Concentration against the failing septic system population. There is a direct correlation between the two, and we see that the failing septic systems will need to be reduced to less than 50 systems before a significant reduction in bacteria will be seen in the watershed.

Septic System Strategy

In our analysis of bacteria sources in the watershed we found that septic systems are highly likely to be the majority source of bacteria in Kiefer Creek, unfortunately this is not an easy issue to rectify. Septic systems are problematic in many watersheds and some good work has been done in Missouri to address failing systems at Table Rock Lake, the Lake of the Ozarks and in the James River Basin. These groups have shown that it is possible to make headway on this issue, but it takes significant time and effort to achieve substantial gains.

One of the major issues with septic systems is the lack of effective regulations. The primary regulatory authority over septic systems falls on the State and County Departments of Health. In St. Louis County there is no effective inspection requirement for septic systems, instead monitoring and enforcement are driven by complaints based on observations of local residents, not water quality considerations. There are many pitfalls in this approach: untrained citizens may not be able to detect a failure, failing systems may evade detection by discharging directly to waterways or groundwater, people may not consider it neighborly to file a complaint, people may not even know that they have to complain to get action, and of course people who think their system may be failing are unlikely to report their neighbor. Another major challenge in addressing septic systems is the cost of implementing long-term solutions like system upgrades and sewer connections. Many of the homes in the Kiefer Creek Watershed that are likely to have failing septic systems are also the lowest valued properties where owners may not have the means to address costly system upgrades or sewer connections.

Another facet of the regulatory framework is the requirement to connect to centralized sewers when a property is within 200 feet of a sewer line and a connection is feasible. Although this regulation has been very effective in new construction, it has fallen short when it comes to properties that were developed prior to the installation of sewer lines. In the Kiefer Creek Watershed we have found many cases where a sewer line is well within 200 feet of a property and a connection is feasible, but there is no sanitary sewer billing record indicative of a sewer connection. It is important to make sure that this provision is being utilized to fully take advantage of the existing sewer infrastructure. When a home with a septic system is connected to the centralized sewer system the system maintenance is no longer the responsibility of the homeowner and the lateral connection to the sewer is covered against failure by the St. Louis County Lateral Program. Upon connection and removal or closure of the septic tank, the bacteria contribution from a home is effectively eliminated, making this an ideal solution in many cases. Lateral line connections are not cheap and can be very costly depending on the distance of the connection and site conditions, which puts a large financial burden on homeowners with fixed and limited incomes.

In developing our septic system strategy we sought to overcome these hurdles by developing best practices that would create a more informed and effective regulatory approach and provide residents with resources to address system issues. The first step is providing comprehensive maintenance information to homeowners with septic systems to reduce system failures due to poor maintenance practices. Next we propose that the county ordinances regarding septic systems be refined to require periodic system inspections and pump-outs, which will help identify failing systems, inadequate system design and/or site conditions, determine where a sewer connection is possible and keep systems from failing in the first place. Inspections should also require that inspection reports be submitted to St. Louis County and MSD to inform current and future decisions regarding sewer infrastructure and the use of public funding to address system failures or construct lateral connections.

If all septic systems in the watershed are inspected, we will find a range of scenarios that need to be dealt with to restore Kiefer Creek to attainment of recreational use standards for bacteria. It is important that the septic system strategy addresses each possible inspection outcome in a way that will result in the elimination of failing septic systems.

Septic System Strategy

Septic Systems with adequate site conditions that cannot be connected to existing sewer lines – Complies with St. Louis County Plumbing Code in terms of parcel size relative to residence occupancy as well as soil conditions. Distance to adjacent sewer lines is greater than 200' or floor elevation is lower than adjacent sewer lines.

- Failing, must be replaced – Poor design must be replaced with a system that complies with current plumbing code
- Failing, must be repaired – Replace broken system components
- Failing, must be maintained – Needs pump-out or other maintenance
- Not Failing – continued maintenance and periodic inspections

Septic Systems with inadequate site conditions that cannot be connected to sewer lines – Does not comply with St. Louis County Plumbing Code in terms of parcel size relative to residence occupancy as well as soil conditions. Distance to adjacent sewer lines is greater than 200' or floor elevation is lower than adjacent sewer lines.

- Failing, (in addition to must be replaced, repaired, maintained) need more land In order for a septic system to function based on occupancy and soil conditions
- Failing, (in addition to must be replaced, repaired, maintained) need to implement alternative technology and/or prioritize in development of infrastructure expansion plan.

Septic Systems that can be connected to sewer lines – Distance to adjacent sewer lines is less than 200' and floor elevation is higher than adjacent sewer lines.

- Failing, Inadequate site conditions – Connect to Sewers
- Failing, adequate sites conditions – Compare Costs of Septic Replacement/Repair/Maintenance to Costs of Lateral Connection

The range of potential scenarios is complex and overlapping, and the management measures that will be most effective in each situation will be subject to significant economic consideration. In some cases the ideal solution will not be available or affordable immediately, so the strategy has to provide both long-term and short-term approaches to impacted homeowners. Because inspections are so important in terms of prioritizing resources and efforts, we propose that they be provided for free to homeowners through state and local funding sources such as the 319 program and the St. Louis County Lateral Program.

In our analysis of bacteria sources in the watershed we found that septic systems are highly likely to be the majority source of bacteria in Kiefer Creek, unfortunately this is not an easy issue to rectify. Septic systems are problematic in many watersheds and some good work has been done in Missouri to address failing systems at Table Rock Lake, the Lake of the Ozarks and in the James River Basin. These groups have shown that it is possible to make headway on this issue, but it takes significant time and effort to achieve substantial gains.

One of the major issues with septic systems is the lack of effective regulations. The primary regulatory authority over septic systems falls on the State and County Departments of Health. In St. Louis County there is no effective inspection requirement for septic systems, instead monitoring and enforcement are driven by complaints based on observations of local residents, not water quality considerations. There are many pitfalls in this approach: untrained citizens may not be able to detect a failure, failing systems may evade detection by discharging directly to waterways or groundwater, people may not consider it neighborly to file a complaint, people may not even know that they have to complain to get action, and of course people who think their system may be failing are unlikely to report their neighbor. Another major challenge in addressing septic systems is the cost of implementing long-term solutions like system upgrades and sewer connections. Many of the homes in the Kiefer Creek Watershed that are likely to have failing septic systems are also the lowest valued properties where owners may not have the means to address costly system upgrades or sewer connections.

Another facet of the regulatory framework is the requirement to connect to centralized sewers when a property is within 200 feet of a sewer line and a connection is feasible. Although this regulation has been very effective in new construction, it has fallen short when it comes to properties that were developed prior to the installation of sewer lines. In the Kiefer Creek Watershed we have found many cases where a sewer line is well within 200 feet of a property and a connection is feasible, but there is no sanitary sewer billing record indicative of a sewer connection.

Septic System Strategy

It is important to make sure that this provision is being utilized to fully take advantage of the existing sewer infrastructure. When a home with a septic system is connected to the centralized sewer system the system maintenance is no longer the responsibility of the homeowner and the lateral connection to the sewer is covered against failure by the St. Louis County Lateral Program. Upon connection and removal or closure of the septic tank, the bacteria contribution from a home is effectively eliminated, making this an ideal solution in many cases. Lateral line connections are not cheap and can be very costly depending on the distance of the connection and site conditions, which puts a large financial burden on homeowners with fixed and limited incomes.

In developing our septic system strategy we sought to overcome these hurdles by developing best practices that would create a more informed and effective regulatory approach and provide residents with resources to address system issues. The first step is providing comprehensive maintenance information to homeowners with septic systems to reduce system failures due to poor maintenance practices. Next we propose that the county ordinances regarding septic systems be refined to require periodic system inspections and pump-outs, which will help identify failing systems, inadequate system design and/or site conditions, determine where a sewer connection is possible and keep systems from failing in the first place. Inspections should also require that inspection reports be submitted to St. Louis County and MSD to inform current and future decisions regarding sewer infrastructure and the use of public funding to address system failures or construct lateral connections to sewer lines.

If all septic systems in the watershed are inspected, we will find a range of scenarios that need to be dealt with to restore Kiefer Creek to attainment of recreational use standards for bacteria. It is important that the septic system strategy addresses each possible inspection outcome in a way that will result in the elimination of failing septic systems in the watershed. The range of potential scenarios is complex and overlapping, and the management measures that will be most effective in each situation will be subject to significant economic consideration. In some cases the ideal solution will not be available or affordable immediately, so the strategy has to provide both long-term and short-term approaches to impacted homeowners. Because inspections are so important in terms of prioritizing resources and efforts, we propose that they be provided for free to homeowners through state and local funding sources such as the 319 program and the St. Louis County Lateral Program.

Septic System BMP Outreach Program

To ensure that all septic system owners have the information available to them it is recommended that all parcels identified as likely to have septic systems be mailed comprehensive information on how to maintain a septic system. This mailing should include a response form that the septic owners can use to send back information regarding their maintenance of their system, and their interest in moving forward with a lateral connection or alternative technology. To achieve the information and education goals of the watershed plan, we propose to implement a Septic System BMP outreach program customized for Kiefer Watershed using information on non-sewered parcels.

SHORT TERM (2015-2020) - Implement a Septic System BMP outreach program to all (<260) non-sewered parcel owners in watershed.

- Conduct outreach campaign via mailing campaign and public signage to explain the scope of problem and recognize early adopters who do what they can at this time to be part of the short-term solution.
- Give the parcel owners something that they can do NOW to begin to address the problem. Be sensitive to the fact that they are private property owners, but raise awareness among the parcel owners and the general park community that the septic waste from less than 260 watershed properties is a danger to Public Health in a State Park with over 650,000 Park Visits per year.
- Parcel Owners will pledge to participate in voluntary program.
- Mapping watershed septic systems - Develop a robust map within CCCW showing the locations of specific properties not served by MSD. St. Louis University/Parks will also use the map to start scoping their aerial thermography initiative for detecting failing septic systems and IDDs.
- Customize an existing septic module of a public outreach campaign. Module is part of an overall social marketing engagement strategy.

(See http://indiana.clearchoicescleanwater.org/septic)

MEASURABLE MILESTONE: 50% Participation

LOAD REDUCTION GOAL**:** 5% (1% per year) reduction in septic system effluent due to improved maintenance practices.

MID TERM (2020-2025) - Enhance existing Septic System BMP program

- Publicly recognize those septic system landowners for participating in the septic system BMP program, Connecting to existing laterals as the Sewer Main Expansion Project continues and taking advantage of cost-share programs.

MEASURABLE MILESTONE: 75% Participation

LOAD REDUCTION**: 7.**5% (0.5%/year) reduction in bacteria load from septic system effluent due to improved maintenance practices.

LONG TERM (Post-2025) - Continue enhancement of Septic System BMP program for septic systems in watershed that are not connected to the sewer mains.

- Recognize those few septic systems that are not able to connect to Sewer Mains.

MEASURABLE MILESTONE: 100% Participation

LOAD REDUCTION: 10% (0.5%/year) reduction in bacteria load from septic system effluent due to improved maintenance practices.

PARTNERS: MSD and the East West Gateway Council can provide informational materials and web content that have been developed to help homeowners manage their septic systems. The Kiefer Creek Watershed Committee will review implementation information on the execution of the strategy, the number of homeowners reached, the number of pledges taken and implementation of recommended BMPs. St. Louis County may also be able to provide support by ensuring that county inspectors and engineers are also part of the group that provides information to homeowners with septic systems, which will benefit all of the watersheds in the county that still have septic systems.

TECHNICAL AND FINANCIAL ASSISTANCE NEEDED

Technical Assistance: None (Existing Program-CCCW)

Financial Assistance: See Education and Outreach section, as Septic System BMP is included in Action Plan.

Sources of Funding: 319 Program, State, Local , Private, Matching from Partners and Participating Residents.

MONITORING – Google Analytics will capture all website metrics, including the # of pledges taken. All information on each pledge taker including name, address, pledge taken, pollution reduction numbers, and 'how did you hear about' details.

Septic System Inspection and Maintenance Requirements and Resources

When a property is being sold a recent inspection of the waste treatment method should be required, just as an inspection of other fundamental systems in a home must be inspected. This should be a requirement for the issuance of an occupancy permit. This inspection should include an evaluation of the site in terms of the 200ft connection rule, which would require connections where possible. If a failing system cannot feasibly be connected to the centralized sewers at the time of sale, the system will need to be fixed and updated to current design standards according to site conditions, or replaced with a more effective alternative waste treatment technology.

The cost of the lateral connection, septic system repairs and upgrades, or an alternative technology should be included in the sale price of the property, thereby financing the upgrades and passing along the improved property value to the new owner without having a major financial impact on the prior owner. In the time between sales and in cases where a sewer connection is not possible, it is important to make sure that septic systems are being properly maintained and periodically inspected.

By requiring a documented pump-out and passing inspection report from a licensed system inspector for all systems every five years, system failures will be detected, addressed and prevented in a timely manner. It is important to ensure that a professional inspection occurs and includes an evaluation of the site in terms of the 200ft sewer connection requirement. If a connection is available there should be a financing instrument available to homeowners to allow them to pay off the cost over time and potentially receive funding to offset the connection cost.

<u>SHORT TERM (2015-2020)</u> – Implement a robust inspection, pump-out and 'time of sale' inspection program based on effective programs in other communities, such as:

- When a property is being prepared for sale it shall have its sewerage system inspected by a licensed inspector, the inspection shall also evaluate the potential to connect to centralized sewers and the applicable regulatory requirements. If the system is found to be failing the cost of needed upgrades, repairs, or optimally a connection to sewers will be included in the sale price of the home and completed prior to the issuance of an occupancy permit.
- Ordinance to require that all St. Louis County citizens that have a septic system on their property are required to have their septic system pumped out and inspected by a licensed sewage handler at least once every five (5) years. Septic system owners may elect, as an alternative to this pump-out requirement, to submit documentation that the system was inspected by a certified operator or on-site soil evaluator within the last 5 years and found to be functioning properly and does not need to be pumped out. A listing of certified operators and on-site soil evaluators will be maintained by the County.
- When there is a proposed change in use or expansion of the facility which requires a building or occupancy permit. This does not mean an inspection is required every time a building permit is needed - only when the use of the facility is changed (e.g., from residential to commercial) or when a facility is expanded (e.g., when a bedroom is added, the square footage of an office building is expanded, or seats are added to a restaurant).
- Any change in the footprint of a building also requires an inspection to determine the location of the system to ensure that new building construction will not take place on top of any system components or on the reserve area of the system. If official records are available to determine the location of the system components, the physical inspection is waived.
- When the property is divided or ownership of two or more properties is combined an inspection should be conducted.

In addition it is very important to support these new requirements with resources to make it as easy as possible for homeowners to comply with the new policies:

- Provide funding for free septic system inspections in conjunction with free or discounted pump-out and time of sale inspection requirement.
- Provide homeowners with the resources needed to finance system upgrades, repairs or sewer connections (see *Lateral Program Funding and Partnerships* and *Neighborhood Improvement District*).
- Help homeowners buying or selling homes with septic systems implement necessary upgrades, repairs or sewer connections

<u>MEASURABLE MILESTONE</u>: Adoption of septic system policy reforms that reduce the number of failing septic systems in the watershed.

Septic System Inspection and Maintenance Requirements and Resources

<u>LOAD REDUCTION GOAL</u>**:** 0% - 10% (5% per year for the first two years after adoption) reduction in septic system effluent due to improved maintenance practices. We expect the policy making process to take 3 to 5 years, load reductions will begin once improved policies have been adopted and are being enforced.

<u>MID TERM (2020-2025)</u> – Enforcement of new septic system requirements in conjunction with resources and support for homeowners needing to make system repairs or sewer connections.

- Septic Systems are inspected periodically and at the time of sale.
- Homes with inadequate system design that can be connected to existing or expanded sewers, are connected.
- Homes with inadequate system design that cannot be connected to existing or expanded sewers are evaluated for alternative solutions (composting toilet, new septic system)
- Routine maintenance is performed on all remaining septic systems.
- Participating and impacted homeowners are provided with sufficient resources and financial tools to expeditiously achieve compliance.

<u>MEASURABLE MILESTONE</u>: During this time period all septic systems in the watershed should be inspected due to the 5 year cycle, including evaluation of system design, sewer proximity and site conditions. 50% of failing systems will either be connected sewers or upgraded to an improved septic system or install a composting toilet.

<u>LOAD REDUCTION</u>**:** 50% - 60% (10% per year upon full implementation of policy and homeowners resources) reduction in septic system effluent due to improved maintenance practices, periodic inspections, system upgrades and new sewer connections.

<u>LONG TERM (Post-2025)</u> Continued Enforcement of septic system requirements in conjunction with resources and support for homeowners needing to make system repairs or upgrades. Increase in sewer connections to expanded sewer infrastructure.

- The second round of inspections will have been completed fostering new connections to new sewer infrastructure.
- Homes with inadequate system design that can be connected to existing or expanded sewers, are connected.
- Homes with inadequate system design that cannot be connected to existing or expanded sewers have implemented alternative solutions to protect recreational use in Kiefer Creek.
- Routine maintenance is performed on all remaining septic systems.
- Participating and impacted homeowners are provided with sufficient resources and financial tools to expeditiously achieve compliance.

<u>MEASURABLE MILESTONE</u>: 85% of failing systems will be connected sewers or upgraded to an improved septic system, composting toilet or other sufficient on-site waste management practice.

<u>LOAD REDUCTION:</u> 80% - 90% (6% – 8% per year upon full implementation of policy and homeowners resources) reduction in septic system effluent due to improved maintenance practices, periodic inspections, system upgrades and new sewer connections

<u>PARTNERS</u>: St. Louis County, East West Gateway Council, MDNR, MDHSS and MSD are the primary partners that will be integral to the development and implementation of policies and provision of resources identified. Homeowners with septic systems should also have a strong voice in this process in order to ensure that the outcome provides a good balance of requirements and resources to achieve compliance.

<u>TECHNICAL AND FINANCIAL ASSISTANCE NEEDED</u>

<u>Technical Assistance</u>: Agency partners with expertise in septic systems, public health, sewers and developing funding for infrastructure will help craft the policy framework and develop homeowner resources.

<u>Financial Assistance</u>: Initial funding of $3000 per year will pay for the coordination of the policy and resource development through the Kiefer Creek Watershed Committee. Once the policies have been adopted substantial additional funding will be needed to support inspections, maintenance and other homeowner resources as well as monitoring of implementation of best management practices.

<u>Sources of Funding</u>: 319 Program, State, Local , Private, Matching from Partners and Participating Residents.

<u>MONITORING</u>

<u>Short Term 2015-2020</u>: Annual evaluation of progress on improved septic system policy and homeowner resources.

<u>Long Term Post-2020</u>: Annual evaluation of inspection results, maintenance practices, upgrades and sewer connections.

Lateral Program Funding and Partnerships

St. Louis County currently includes a $28 lateral program fee in the annual property taxes on all residential parcels, and the funds are to be used to repair broken lateral lines, but currently cannot be used to establish new lateral connections. The basis of the lateral program and centralized infrastructure overall, is to reduce wastewater issues in valuable local water resources. Kiefer is a highly valued local stream that is easily and readily accessed in Castlewood State Park. Using lateral program funds to resolve issues with outdated infrastructure in the Kiefer Watershed would be in-line with the underlying goals of the program, protecting what is arguably the most highly valued small stream in our region. In addition, it makes sense to use any other available funding source to further encourage connection to centralized sewers where possible. At the state level there are both 319 funds and State Revolving Load funds that may be available to help offset or defer the costs of installing new lateral connections in the watershed.

These connections will result in increased property value and elimination of septic system maintenance costs, but will add a monthly sanitary sewer bill. The cost of sewer service is comparable to the cost of proper septic system maintenance and repair. In a loan-based program there may be a way to recoup the loan balance at the time of sale under the reasoning that the home sale price has increased due to the lateral connection. Following this line of reasoning, expedited connections could be made with a provision allowing for the cost to be paid when the home is sold at a future date.

SHORT TERM (2015-2020) The lateral program funding structure is changed to allow for use to create new lateral connections on homes with failing septic systems that can be connected to existing sewers.
MEASURABLE MILESTONE: Partners develop proposed changes to lateral program funding structure and build support for changes.
LOAD REDUCTION: Reductions have been included in the *Septic System Inspection and Maintenance Requirements and Resources*.

MID TERM (2020-2025) Lateral program funding is used to connect septic systems to existing sewer infrastructure.
MEASURABLE MILESTONE: Lateral program is modified to allow for funding of new lateral connections to connect homes currently on septic systems into existing sewer lines.
LOAD REDUCTION: Reductions have been included in the *Septic System Inspection and Maintenance Requirements and Resources*.

LONG TERM (Post-2025) Lateral program funding is used to connect septic systems to expanded sewer infrastructure
MEASURABLE MILESTONE: Lateral program funds are employed to connect homes with septic systems to expanded sewer infrastructure.
LOAD REDUCTION: Reductions have been included in the *Septic System Inspection and Maintenance Requirements and Resources*.

PARTNERS: St. Louis County, East West Gateway Council and MSD should work together to assess the best way to use lateral program funds to reduce failing systems through connections to existing and expanded sewer lines.

TECHNICAL AND FINANCIAL ASSISTANCE NEEDED
Technical Assistance: St. Louis County, MSD and East West Gateway Council should work together to come up with beneficial changes to the way Lateral Program funds can be used and develop additional funding resources.
Financial Assistance: Included in the *Septic System Inspection and Maintenance Requirements and Resources*.
Sources of Funding: 319 Program, State, Local , Private, Matching from Partners and Participating Residents.

MONITORING
Short Term 2015-2020: Annual evaluation of progress on improved lateral funding structure development and adoption.
Long Term Post-2020: Annual evaluation of use of lateral program funds to connect homes on septic systems to existing sewer lines.

Formation of a Neighborhood Improvement District

Funding is going to be a major hurdle to overcome in eliminating failing septic systems in the watershed, each failing system represents a potential cost of more than $15,000 to replace or repair a septic system, or construct a lateral connection. This upfront cost makes it unlikely that homes will be proactive in connecting to sewers, especially where people have lower or fixed incomes. This means that progress in reducing bacteria in the watershed would be dependent on a time of sale requirement that could take decades to impact enough of the failing systems. Just because the sewers have expanded, doesn't mean that homes are necessarily connected to them, as we see in the current conditions in the watershed. When new sewers are built how do we ensure that all homes that can connect do, and how can we make it easier for homeowners to implement connections as soon as possible? A neighborhood improvement district would create a pool of low-interest loan funding that could be used to complete connections ASAP and be paid back in small installments over time by the homeowner, the balance of the loan being paid at the time of the home sale or carrying over to the new owner. Some financial mechanism must be made available in order to expedite the reduction of bacteria in the watershed.

The Neighborhood Improvement District Act, Sections 67.453 through 67.475, RSMo, was adopted by the Missouri General Assembly in 1990 for the purpose of stimulating development of public improvements that in turn will stimulate private development. The act provides a method by which political subdivisions of the State may issue general obligation bonds upon a petition or vote of the residents within an area known as a neighborhood improvement district, which would be benefited by the public improvements and would be specially assessed to reimburse the political subdivision for its costs. A Neighborhood Improvement District is formed as a cooperative effort between the county and residents within a proposed district. The county's role is to coordinate efforts and provide engineering, inspection, and financial support. Communities that utilize this program are given the opportunity to pay for the improvement as either a lump sum or through special assessments, which can be financed for 10 or 20 years.

SHORT TERM (2015-2020) Form a Neighborhood Improvement District that can secure funding to provide homeowners with low or no-interest loans to expedite implementation of sewer connections, system repairs and system upgrades.
MEASURABLE MILESTONE: Implement a Neighborhood Improvement District to assist in funding private lateral sewer connections to existing sewer mains.
LOAD REDUCTION: Reductions have been included in the *Septic System Inspection and Maintenance Requirements and Resources*.

MID TERM (2015-2020) Neighborhood Improvement District secures funding to provide homeowners to expedite implementation of sewer connections, system repairs and system upgrades.
MEASURABLE MILESTONE: Funding is secured by the Neighborhood Improvement District to resolve septic system failures.
LOAD REDUCTION: Reductions have been included in the *Septic System Inspection and Maintenance Requirements and Resources*.

LONG TERM (Post-2025) Neighborhood Improvement District disburses funding to provide homeowners to expedite implementation of sewer connections, system repairs and system upgrades.
MEASURABLE MILESTONE: Neighborhood Improvement District Funding is utilized to assist homeowners in resolving septic system failures.
LOAD REDUCTION: Reductions have been included in the *Septic System Inspection and Maintenance Requirements and Resources*.

PARTNERS: St. Louis County and Kiefer Creek Watershed Residents should work together to develop a Neighborhood Improvement District.
TECHNICAL AND FINANCIAL ASSISTANCE NEEDED
Technical Assistance: MSD and East West Gateway Council can provide support in developing a strong neighborhood improvement district approach to addressing septic system problems in the watershed.
Financial Assistance: Included in the *Septic System Inspection and Maintenance Requirements and Resources*.
Sources of Funding: 319 Program, State, Local , Private, Matching from Partners and Participating Residents.

MONITORING: St. Louis County Reporting, Coordination and implementation review with Kiefer Creek Watershed Group, Citizen monitoring of implementation results, provide public input on success.

Sewer Infrastructure Expansion

When septic systems are replaced with lateral connections the maintenance responsibility is taken care of by St. Louis County and MSD, eliminating the burden on the homeowner to understand how to maintain their system and have it professionally inspected and repaired. For these reasons there is good cause to consider the potential to expand the reach of sewer infrastructure in the watershed to allow more homeowners to connect to the sewer system. It is worth noting however that in some cases the expansion of sewer infrastructure could spur an increase in development of areas in the watershed.

In expanding the sewer infrastructure there are many factors to consider and it is important to prioritize the investments that will have biggest impact on helping Kiefer Creek achieve compliance with the recreational use criteria for bacteria. There are currently an estimated 66 miles of sewers in the watershed which serve over 3000 parcels. In the areas just upstream from Castlewood State Park, where the highest concentration of problematic septic systems are located, we estimate that the installation of around 2 miles of sewer lines would allow all of these homes to be connected to the centralized sewers. An additional estimated 4.5 miles of sewers would allow all but 25 to 30 septic systems in the watershed to be replaced with lateral connections.

To move forward with an effort to expand sewer infrastructure a feasibility study should be conducted to establish the costs, requirements, constraints and timeframe for expanding infrastructure into these areas. Under Section 604b of the Clean Water Act the regional planning authority is allowed funding to develop a feasibility study. This process would be led by the East/West Gateway Council in close coordination with MSD, St. Louis County and impacted watershed residents.

Although the entire watershed falls within the service area of MSD, a sub-districting process may be required to implement an expansion of the sewer lines in the watershed. It is unclear if all potentially connected septic systems would be required to immediately connect when new sewers were laid. However, just by being available the new sewer lines would amplify the potential impact of the time of sale policy change clearing the way to a clean and safe Kiefer Creek.

SHORT TERM (2015-2020) Conduct a Kiefer Watershed Sewer Expansion Feasibility Study.

- 260 private residences in the watershed have been identified as the overwhelming source of fecal bacteria in Kiefer Creek. Long-term solution to this problem may require the elimination of most or all septic systems. Conduct a Kiefer Watershed Sewer Expansion Feasibility Study to determine cost and benefits of an increase in main sewer infrastructure.

MEASUREABLE MILESTONE: Feasibility Study is completed
LOAD REDUCTION: Reductions have been included in the *Septic System Inspection and Maintenance Requirements and Resources*.

MID TERM (2020-2025) Implement recommendations of Sewer Expansion Feasibility Study
MEASUREABLE MILESTONE: :Implement recommendations of Sewer Expansion Feasibility Study. Begin construction, if recommended
LOAD REDUCTION: Reductions have been included in the *Septic System Inspection and Maintenance Requirements and Resources*.

LONG TERM (Post-2025) Complete recommendations of Sewer Expansion Feasibility Study
MEASUREABLE MILESTONE: :Complete implementation and construction recommended in the feasibility study.
LOAD REDUCTION: Reductions have been included in the *Septic System Inspection and Maintenance Requirements and Resources*.

PARTNERS: East West Gateway Council and MSD will be the lead partners on this effort with engagement from St. Louis County, Kiefer Creek Watershed Group and watershed residents.

TECHNICAL AND FINANCIAL ASSISTANCE NEEDED
Technical Assistance: East-West Gateway, Saint Louis Metropolitan Sewer District, St. Louis County Department of Health, St. Louis County Government
Financial Assistance: Included in the *Septic System Inspection and Maintenance Requirements and Resources*.
Sources of Funding: 319 Program, State, Local , Private, Matching from Partners and Participating Residents.

MONITORING: East-West Gateway, MSD, St. Louis County, and Kiefer Creek Watershed Group will coordinate and track development and implementation of feasibility study.

Direct Use of 319 Funds to Eliminate Failing Septic Systems

Changing the policies that regulate septic systems and creating financing tools for system repairs, upgrades, will take years to succeed and more years after that to be fully implemented and enforced. If Section 319 funding could be used directly to fix failing septic systems, replace insufficiently designed systems or construct later connections to sewer lines, then action could be taken quickly to make significant reductions in the bacteria load that impairs Kiefer Creek. This approach would be expensive with each failing system requiring an investment of up to $25,000. There are a number of potential ways to leverage and prioritize 319 funding to get the most out of this investment. Instead of just giving out the funds, they could be structured as loans or a combination of direct funding and a low interest loan. 319 funds could also potentially be matched with funding from the St. Louis County Lateral Program, a Neighborhood Improvement District, local benefactors that love Castlewood as much as we do or crowdfunding for that matter. In some cases homeowners may be able to provide matching by restoring riparian corridors and planting trees, installing horse waste management BMPs and improving pasture management, or making other types of valuable investments in the long term health of Kiefer Creek. Funding can also be prioritized based on an evaluation of the inspection findings and current infrastructure in the watershed to identify the repairs and lateral connections that will be the least costly and provide the greatest degree of water quality protection. In order to clean up Kiefer Creek we need to make it as easy as possible for watershed stakeholders to take the appropriate actions.

SHORT TERM (2015-2020) Evaluate the potential to use 319 funding to fix broken septic systems, install new systems or system components, construct lateral connections to sewer lines or install an alternate technology. Review existing information and collect additional information from septic system inspections to inform cost estimates and prioritization of investments. Identify and engage with potential sources of matching, prepare 319 proposal requesting funding to make priority investments.
MEASUREABLE MILESTONE: :A process is undertaken to evaluate and pursue 319 funding supported by an assessment of existing conditions and inspection data and an effective campaign to build support matching through local partners and watershed residents.

LOAD REDUCTION: The load reductions will be highly dependent upon on the timeframe needed to prepare a strong proposal and begin deploying funding resources to address priority system failures and the amount of funding provided. For every failing septic system that is addressed the potential septic system bacteria reduction is 0.75% – 1.5% depending on the total number of failing systems. If 5 systems can be addressed within the next five years there is a potential bacteria load reduction of 3.75% - 7.5%.

MID TERM (2020-2025) Utilize 319 grant funds in conjunction with other funding sources to implement priority lateral connections, septic system repairs and replacement or install alternate technologies.
MEASUREABLE MILESTONE: $50,000 - $100,000 in 319 funds, and the necessary matching funds, are secured and utilized.
LOAD REDUCTION: 3.75% - 15% (5 – 10 failing systems addressed)

LONG TERM (Post-2025) Utilize 319 grant funds in conjunction with other funding sources to implement priority lateral connections, septic system repairs and replacement or install alternate technologies.
MEASUREABLE MILESTONE: $100,000 - $200,000 in 319 funds, and the necessary matching, are secured and utilized.
LOAD REDUCTION: 15% - 30% (15 – 20 failing systems addressed)

PARTNERS: Support of this approach by the Missouri Department of Natural Resources will be critical to its success. MSD and East West Gateway Council will be able to help develop priorities and sensible financial tools to expedite bacteria load reductions. The Kiefer Creek Watershed Group can assist in pulling together the support and engagement of watershed residents in this process.

TECHNICAL AND FINANCIAL ASSISTANCE NEEDED
Technical Assistance: St. Louis County can provide assistance in inspecting and permitting composting toilets in residential settings.
Financial Assistance: Included in the *Septic System Inspection and Maintenance Requirements and Resources*.
Sources of Funding: 319 Program, State, Local , Private, Matching from Partners and Participating Residents.

MONITORING:MDNR, MSD, East West Gateway Council and the Kiefer Creek Watershed Group will work together to coordinate and track implementation progress.

Alternative Technology to Eliminate Septic Runoff: Composting Toilets

No longer limited to remote areas where water is scarce, composting toilets have been making a positive impact on water quality by eliminating pathogens and conserving water. Because composting toilets eliminate the need to flush toilets, this significantly reduces water use and allows for the recycling of valuable plant nutrients. Composting toilets contain, immobilize, and destroy pathogens using heat and aerobic decomposition, reducing the risk of human infection to acceptable levels without contaminating the environment. There is no smell associated with composting toilets. Correctly installed and operating composting toilet will not smell because there is a positive suction of air through the toilet at all times. The convenience behind a composting toilet is that it can be installed anywhere unlike a septic system or sewer line.

Waterless toilets can be used in all types of conditions and areas including areas with: low percolation, high water tables, shallow soil, or rough terrain. Composting toilets are relatively inexpensive as compared to septic systems and lateral connections however they may be difficult for many people to accept because the waste does not just 'go away.' Composting toilet systems do require some maintenance, electricity and well thought out siting and installation. Once a toilet has been installed the long-term maintenance costs are very low, making this practice preferable to either a septic system or a sewer connection for those willing to make the initial investment and can handle the basic maintenance requirements.

SHORT TERM (2015-2020) Provide composting toilet information to homeowners that have failing systems, and are unable to connect to centralized sewers.
MEASUREABLE MILESTONE: :All homeowners outside of the range of existing sewer infrastructure are provided with information on composting toilets as part of the information and outreach campaign.
LOAD REDUCTION: Reductions have been included in the *Septic System Inspection and Maintenance Requirements and Resources*.

MID TERM (2020-2025) Composting toilets are implemented in situations where no other solution is available or the homeowners are willing to maintain the system in order to save on long term costs.
MEASUREABLE MILESTONE: 50% of failing septic systems beyond the range of existing sewers have been replaced with composting toilets.
LOAD REDUCTION: Reductions have been included in the *Septic System Inspection and Maintenance Requirements and Resources*.

LONG TERM (Post-2025) Composting toilets are fully implemented in all appropriate situations in the watershed.
MEASUREABLE MILESTONE: :100% of failing septic systems beyond the range of expanded sewers have been replaced with composting toilets.
LOAD REDUCTION:Reductions have been included in the *Septic System Inspection and Maintenance Requirements and Resources*.

PARTNERS: MSD, East West Gateway Council and the Kiefer Creek Watershed Group can assist in this approach by identifying cases where there is no possible sewer connection and site conditions are prohibitive of a septic systems or the resident wishes to employ this technology because of its low cost. With multiple residents on-board, it may be possible to partner with a manufacturer and installer to get a group discount. St. Louis County can also help with the acquisition of the necessary permits and inspections needed to implement a composting toilet that complies with the county plumbing code.

TECHNICAL AND FINANCIAL ASSISTANCE NEEDED
Technical Assistance: St. Louis County can provide assistance in inspecting and permitting composting toilets in residential settings.
Financial Assistance: Included in the *Septic System Inspection and Maintenance Requirements and Resources*.
Sources of Funding: 319 Program, State, Local , Private, Matching from Partners and Participating Residents.

MONITORING St. Louis County, MSD and East West Gateway can keep track of parcels where this is the best approach and the Kiefer Creek Watershed Group can track engagement efforts and implementation of composting toilet systems in the watershed.

Pet and Wildlife Waste Management

Cleanup of domestic animal waste before rain events is the most effective way to prevent waste from washing into the creek. Landowners could make an additional impact by periodically cleaning up wildlife waste from yards and impervious surfaces. When native wildlife defecates on a non-native mown lawn, sidewalk or driveway there is the potential for this waste to be carried quickly through the stormwater system and into the stream channel by a rain event. Watershed residents should be encouraged to cleanup all waste that they find in non-forested/non-native landscapes, especially in areas where stormwater inlets or flow channels are in close proximity. Waste from both pets and wildlife (geese, turkey, deer, raccoon, coyote, etc.) should be removed from these areas to reduce the transport of bacteria from this source.

Implementation of a pet and wildlife waste cleanup project should include distribution of information about pet and wildlife waste cleanup to watershed stakeholders. We can also encourage cleanup with the placement of bag dispensers in neighborhoods and include materials about the watershed restoration effort to engage and inform more members of the community.Although many people in the watershed have yards where most of the waste is likely to be deposited, the placement of bag dispensers *with* information in neighborhoods will be a good way to remind people why this practice is important and encourage them to do a good job. Pet waste cleanup can also be encouraged by inclusion of information on cleaning up pet waste in municipal and sewer district mailings to residents.

Pet waste concentrations are likely to be highest in areas where there are the most people living, these are also the areas with the most intensive stormwater infrastructure that delivers bacteria from pet waste quickly to the stream channel during rain events. It makes sense to implement a strategy that focuses on the areas with the greatest density of housing units. This could be achieved by placing informative bag dispensers based on the number of housing units per a given area, with approximately 3900 housing units in the watershed a distribution of 1 dispenser for every 100 housing units would require 39 bag dispensers. In addition, it is a good idea to install multiple dispensers in Castlewood State Park and Bluebird Park, and one in the Klamberg Conservation Area where many people will take their dogs on walks.

<u>SHORT TERM (2015-2020)</u> Install the first 25 pet waste bag dispensers and launch outreach strategy.

- Conduct outreach campaign via mailing campaign and public signage to explain the scope of problem and recognize early adopters.
- Give the pet owners something that they can do NOW to begin to address the problem and additional information on the watershed.
- Pet Owners will pledge to participate in voluntary program.
- Utilize the pet waste module of a public outreach campaign. Module is part of an overall social marketing engagement strategy.

<u>MEASUREABLE MILESTONE</u>: Pet waste dispensers are installed and refilled with bags and info pamphlets periodically. # of Pledges
<u>LOAD REDUCTION:</u> 10% of bacteria load from pet waste

<u>MID TERM (2020-2025)</u> Install the next25 pet waste bag dispensers.
<u>MEASUREABLE MILESTONE</u> Additional pet waste bag dispensers are install and periodically refilled with bags and info pamphlets. # of Pledges
<u>LOAD REDUCTION:</u> 20% of bacteria load from pet waste

<u>LONG TERM (Post-2025)</u> Continued maintenance.
<u>MEASUREABLE MILESTONE</u>: Periodic refill of bags and info pamphlets. # of Pledges Taken
<u>LOAD REDUCTION:</u> 25% of bacteria load from pet waste

<u>PARTNERS</u>: This BMP offers a perfect opportunity partner with local scouts, shop classes and volunteers on the construction, installation and maintenance of the pest waste bag/info dispensers.

<u>TECHNICAL AND FINANCIAL ASSISTANCE NEEDED</u>
Pet waste bag dispensers with printed information about cleaning up waste designed for use in public spaces cost from $70 (basic, small, limited information, plastic) to $200 (includes trash bin, larger information panel, metal) to purchase, plus from $20-$40 to install and $30/yr for bags per dispenser. To save costs and provide matching, dispensers could also be constructed and installed by volunteers such as scouts or watershed volunteers.
<u>Sources of Funding</u>: 319 Program, State, Local , Private, Matching from Partners and Participating Residents.

<u>MONITORING</u>: Kiefer Creek Watershed Committee and watershed volunteers can track the use of pet waste bags, pamphlets and pledges.

Horse Manure Management: Nutrient Management Plans

A Nutrient Management Plan (NMP) is a farm-specific document designed to help farmers minimize nutrient runoff into local streams and rivers within a watershed. NMP's keep track of the amount, time, and application of manure on a farm. NMP's can also work to balance farm profits by implementing cost-effective alternatives to waste management. A Nutrient Management Strategy provides storage and destination ideas for managing manure produced within a farm. To accommodate specific needs of a Nutrient Management Plan a horse owner may be able to consult with the Soil and Water Conservation District. In order to utilize the service of the NRCS in composing a nutrient management plan a horse owner must first register with the FSA as a farm which requires that the landowner has three or more acres of land used agriculturally. Keeping, raising and stabling horses is considered an agricultural practice that is eligible for cost-share and professional consultation with the St. Louis County SWCD. Many of the horse owners in the Kiefer Creek Watershed are probably unaware of the benefits of a nutrient management plan and the support offered through the NRCS and the SWCD.

- The first step in implementing this practice is to provide horse owners with three or more acres of land with information on how they can begin working with the SWCD.
- It is also recommended that meetings between horse owners and a representative of the SWCD be conducted to provide in-depth information about the services offered and allow the owners to ask specific questions about the program.

SHORT TERM (2015-2020) Provide horse owners with SWCD information and connect with SWCD representatives.
MEASUREABLE MILESTONE: All horse owners provided with information on Nutrient Management Plans for equestrian operations. Meetings coordinated and held between horse owners and SWCD representatives. 10% of horse owners with >3 acres have nutrient management plans.
LOAD REDUCTION:5% reduction in bacteria loading from horses.

MID TERM (2020-2025) Watershed Horse owners with >3 acres have completed and are implementing Nutrient Management Plans.
MEASUREABLE MILESTONE: 25% of horse owners with >3 acres have Nutrient Management Plans
LOAD REDUCTION: 10% reduction in bacteria loading from horses.

LONG TERM (Post-2025) Watershed Horse owners with >3 acres have completed and are implementing Nutrient Management Plans.
MEASUREABLE MILESTONE: 75% of horse owners with >3 acres have Nutrient Management Plans.
LOAD REDUCTION:25% reduction in bacteria loading from horses.

PARTNERS: The primary partner on this practice will be the St. Louis County Soil and Water Conservation District. The Missouri Department of Conservation can also provide expertise and resources for horse owners. Within the watershed the horse owners and the stables will be critical partners to achieving implementation of nutrient management plans and will provide important input and feedback on this practice.

TECHNICAL AND FINANCIAL ASSISTANCE NEEDED
Technical Assistance: The primary technical assistance will come from the St. Louis County Soil and Water Conservation District, additional assistance may be available through the NRCS and MDC.
Financial Assistance: Funding should be provided to help cover the cost of developing Nutrient Management Plans, later the same funding sources and cost-share can be used to implement nutrient reduction strategies.
Sources of Funding: 319 Program, State, Local , Private, Matching from Partners and Participating Residents.

MONITORING: St. Louis County SWCD will be able to keep track of development of NMPs in the watershed and the Kiefer Creek Watershed Group can support outreach and engagement through the CCCW model.

Horse Manure Management: Simple Best Management Practices

Improved Manure Storage – Often times it may be the case that the location of manure piles and the design of storage area have not been considered in terms of reducing runoff to the stream. Ideally a manure pile will be located as far from the nearest stream channel or flow path as is possible on a given lot. In addition it is recommended that the location of the pile be graded to drain inwards and that the pile be covered by a roof or a weighted tarp to prevent any runoff.

Composting Horse Manure – When properly treated, horse manure is a valuable commodity for replenishing and fertilizing depleted soil, and it is wasteful and harmful to let it wash into Kiefer Creek. If properly composted, the manure from the horses in the Kiefer Creek Watershed could be put to good use rebuilding the watershed soils that were depleted in the course of development and deforestation.

Grazing Area Cleanup/Harrowing – Horse pastures should be harrowed periodically to break up the manure and make the nutrients more accessible to the grasses. The potential for bacteria from manure to enter the stream channel can be further reduced by cleaning up manure in areas with high slopes, riparian buffer zones, and in areas where there isn't a healthy vegetative land cover. Targeted area cleanup could be expedited by placing manure composters in multiple locations.

SHORT TERM (2015-2020) - Provide all horse owners with information about simple best management practices and programs and funding available to help with implementation.
MEASUREABLE MILESTONE: All horse owners have been provided with information and have begun implementing practices by covering manure piles, composting manure for reuse and improving management and cleanup of grazing areas.

- Conduct outreach campaign via mailing campaign and public signage to explain the scope of problem and recognize early adopters.
- Give the horse owners something that they can do NOW to begin to address the problem.
- Horse Owners will pledge to participate in voluntary program.
- Create a horse waste module of a public outreach campaign. Module is part of an overall social marketing engagement strategy.

LOAD REDUCTION: 10% reduction in bacteria load from horse manure.

MID TERM (2020-2025) Provide all horse owners with information about simple best management practices and programs and funding available to help with implementation.
MEASUREABLE MILESTONE: All horse owners have been provided with information and have continued and expanded implementation of best practices by covering manure piles, composting manure for reuse and improving management and cleanup of grazing areas.
LOAD REDUCTION: 20% reduction in bacteria load from horse manure.

LONG TERM (2020-2025) Provide all horse owners with information about simple best management practices and programs and funding available to help with implementation.
MEASUREABLE MILESTONE: All horse owners have been provided with information and have continued and expanded implementation of best practices by covering manure piles, composting manure for reuse and improving management and cleanup of grazing areas.
LOAD REDUCTION: 30% reduction in bacteria load from horse manure.

PARTNERS: The St. Louis County SWCD and MDC could provide technical support and some cost-share resources through a partnership with horse owners through the CCCW module and the Kiefer Creek Watershed Group.

TECHNICAL AND FINANCIAL ASSISTANCE NEEDED
Technical Assistance: The primary technical assistance will come from the St. Louis County Soil and Water Conservation District, additional assistance may be available through the NRCS and MDC.
Financial Assistance: Funding should be made available to help offset the cost of implementing best management practices and cost-share programs should be utilized. Most practices can be achieved very inexpensively relative to the overall cost of horse ownership, it may even be possible to offset implementation costs commodifying the composted manure.
Sources of Funding: 319 Program, Cost-Share Program, State, Local , Private, Matching from Partners and Participating Residents.

MONITORING: St. Louis County SWCD , Kiefer Creek Watershed Group and MDC can track use of BMP resources and collect feedback.

Water Quality Assessment: Chloride

- Designated Use Impairment & Water Quality Standards
- Water Quality Monitoring Data & Source Assessment
- Macroinvertebrate Sampling Data
- Pollution Reduction Strategies & BMPs

In 2012 Kiefer Creek was listed as impaired for aquatic life use due to high levels of chloride, which was result of analyses of monitoring data conducted by the MSD. Chloride aka salt, is an essential material for life on earth, however too much salt can be very detrimental to an ecosystem. When salt migrates into lakes and streams, it can harm aquatic plants and kill off freshwater organisms. A heavy influx of sodium and chloride ions will leave aquatic organisms vulnerable to survival, growth, or reproductive risks. Salt can also inhibit plant's water absorption and stunt root growth, interfering with the uptake of plant nutrients and inhibiting the plant's long-term growth. This may in-turn, lead to habitat degradation.

Most chloride pollution enters waterways through stormwater runoff during winter months when roads, driveways, and sidewalks are heavily salted in order to de-ice and ensure safe road conditions. As the snow and ice melts, it carries the salt with it into stormwater inlets along roads and parking lots, allowing the pollution to quickly make its way into Kiefer Creek. This is an issue that follows development and is widespread among streams with developed watersheds in the St. Louis Region. Although there is a necessity in keeping routes clear for travel during winter months, there are ways to ensure that salt is not being wasted through inefficiencies.

In some cases industrial activities and poor salt storage can result in an impairment, but there are no industrial chloride effluent flows or salt storage facilities or areas that have been identified in the watershed. Another potential source are swimming pools, which are likely to be emptied into a stormwater inlet, delivering chloride to Kiefer Creek in the form of chloride. Because the only significant chloride pulses detected in the watershed have occurred during winter months it is likely that the most acute loading comes from road salt.

For reference, here is the equation used to calculate the magnitude of the chloride impairment according to the Missouri numeric water quality standard for chloride:

Pollutant (mg/L) AQL

Non-Metals (Hardness Dependent)

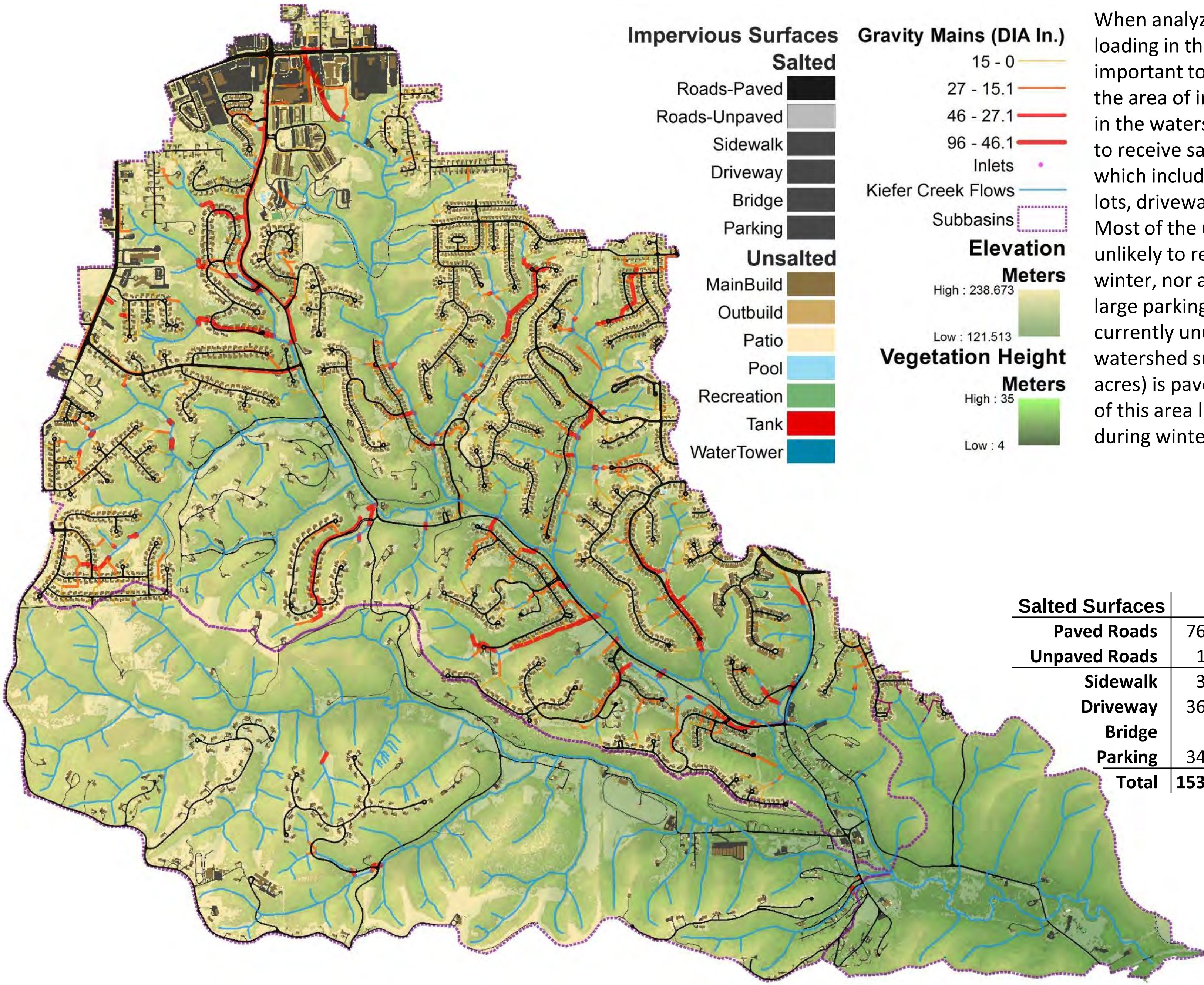
Chloride (mg/L) Acute: $287.8 * (\text{Hardness})^{0.205797} * (\text{Sulfate})^{-0.07452}$

Chronic: $177.87 * (\text{Hardness})^{0.205797} * (\text{Sulfate})^{-0.07452}$

Sulfate (mg/L)	Chloride, Cl- (mg/L)		
Hardness, H (mg/L)	Cl- < 5	5 ≤ Cl- < 25	25 ≤ Cl- ≤ 500
H < 100	500	500	500
100 ≤ H ≤ 500	500	S1	S2
H > 500	500	2,000	2,000

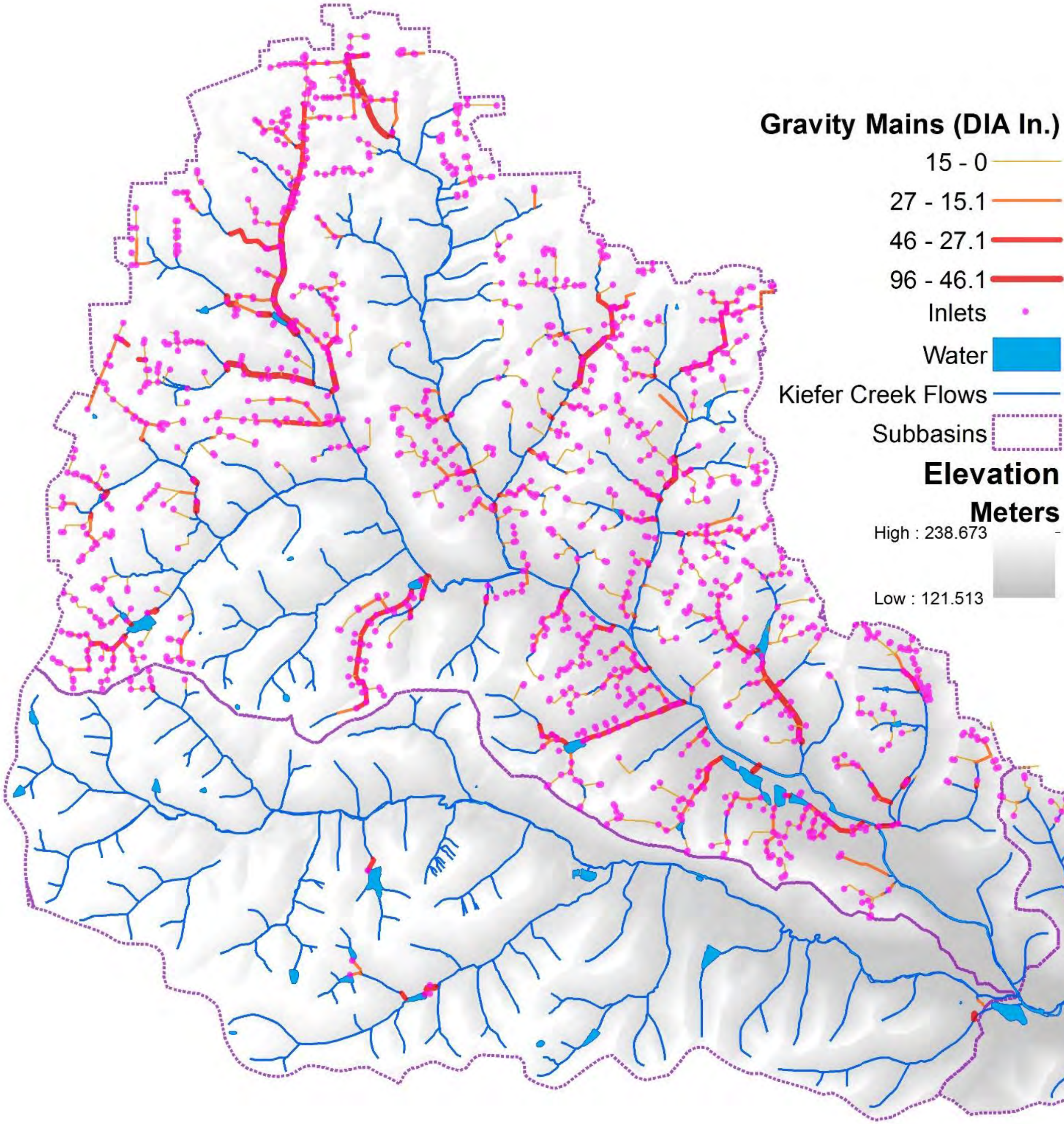
S1 = [-57.478 + 5.79 (hardness) + 54.163 (chloride)] * 0.65

S2 = [1276.7 + 5.508 (hardness) − 1.457 (chloride)] * 0.65



When analyzing the chloride loading in the watershed it is important to take into account the area of impervious surfaces in the watershed that are going to receive salt in the winter which includes roads, parking lots, driveways and sidewalks. Most of the unpaved roads are unlikely to receive salt in the winter, nor are some of the large parking areas which are currently unused. 8.2% of the watershed surface area (352 acres) is paved over, and much of this area likely receives salt during winter weather.

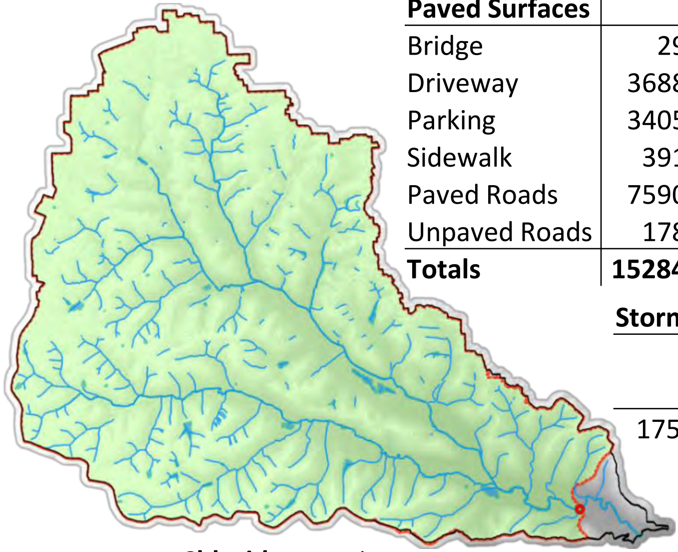
Salted Surfaces	Ft^2	% of Watershed
Paved Roads	7604492	4.062%
Unpaved Roads	188720	0.101%
Sidewalk	396318	0.212%
Driveway	3688761	1.970%
Bridge	29051	0.016%
Parking	3436259	1.835%
Total	**15343601**	**8.195%**



In addition, the amount of stormwater infrastructure in the basin is also important to consider. Stormwater inlets and storm sewers often provide a direct route to the stream with little opportunity for the concentrated runoff to dissipate into the soils.
In the following assessment of the chloride monitoring data we have included the breakdown of impervious surfaces that are likely to receive road salt during winter weather, as well as a measurement of the stormwater infrastructure by catchment area. Some stormwater infrastructure includes ponds that may help dilute chloride pulses into Kiefer Creek.

Stormwater Infrastructure

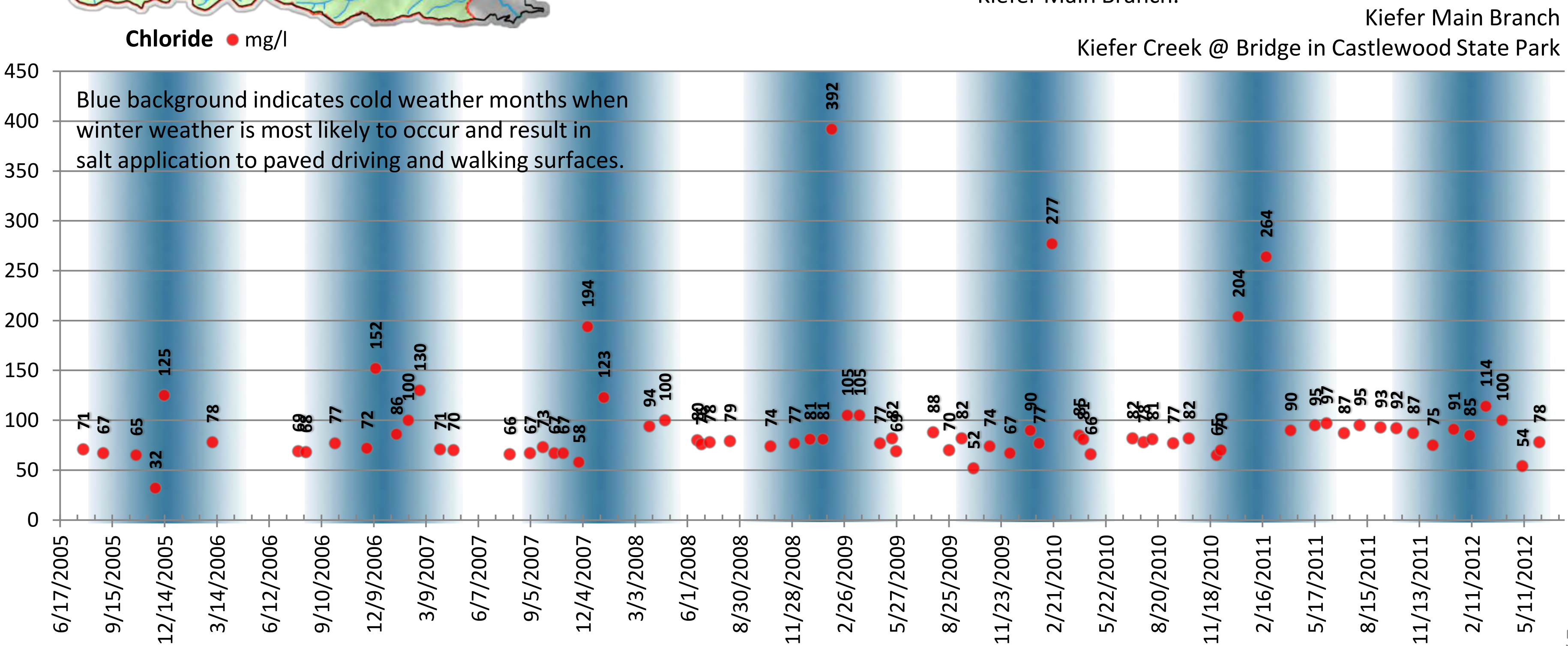
1395	Stormwater Inlets
0.32	Stormwater Inlets/Acre
175898.0	Linear Feet of Storm Sewers
40.9	Ft of Storm Sewers/Acre

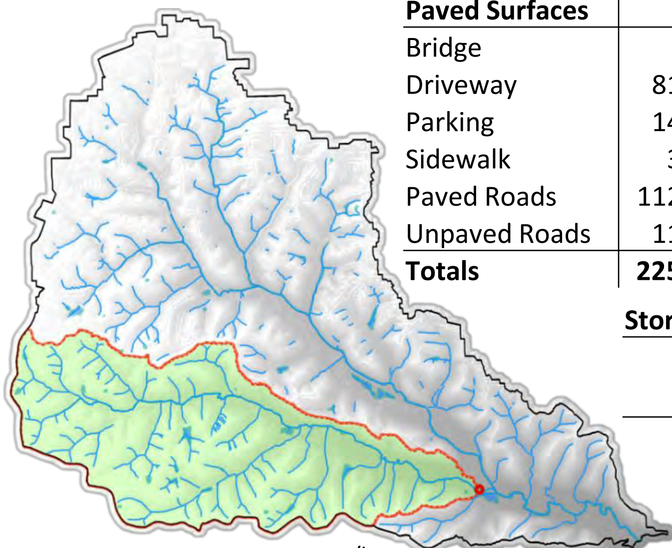


Paved Surfaces	Ft²	% of Total Paved Surfaces	Ft² Per Acre of Catchment
Bridge	29050.7	0.189%	6.83
Driveway	3688760.9	24.041%	867.54
Parking	3405677.3	22.196%	800.96
Sidewalk	391814.6	2.554%	92.15
Paved Roads	7590523.8	49.470%	1785.17
Unpaved Roads	178349.9	1.162%	41.94
Totals	**15284177.3**	**99.613%**	**3594.59**

Stormwater Infrastructure	
1395	Stormwater Inlets
0.33	Stormwater Inlets per Acre
175898.0	Feet of Storm Sewers
41.4	Ft of Storm Sewers per Acre

The data from the Kiefer Main Branch shows a clear increase during winter months. This testing location is below the confluence of the two subbasins, so all of the upstream surfaces essentially drain to this point. We can infer that the majority of this loading is coming from the Kiefer Spring Branch, because the Sontag Spring Branch does not display the same acute levels as we see below, and because the Kiefer Spring Branch of the watershed contains 82% of the impervious area in the watershed, it is believed that this portion of the watershed contributes the majority of the chloride during winter months. Because the data collected on the main branch is diluted by the lower concentration of chloride in the Sontag Spring Branch, the load coming from the Kiefer Spring Branch must be of a higher concentration measured in the Kiefer Main Branch.





Paved Surfaces	Ft²	% of Total Paved Surfaces	Ft² Per Acre of Catchment
Bridge	6120.1	0.040%	4.62
Driveway	815598.2	5.316%	615.08
Parking	149581.9	0.975%	112.81
Sidewalk	37329.5	0.243%	28.15
Paved Roads	1126006.3	7.339%	849.18
Unpaved Roads	119043.6	0.776%	89.78
Totals	**2253679.6**	**14.688%**	**1699.61**

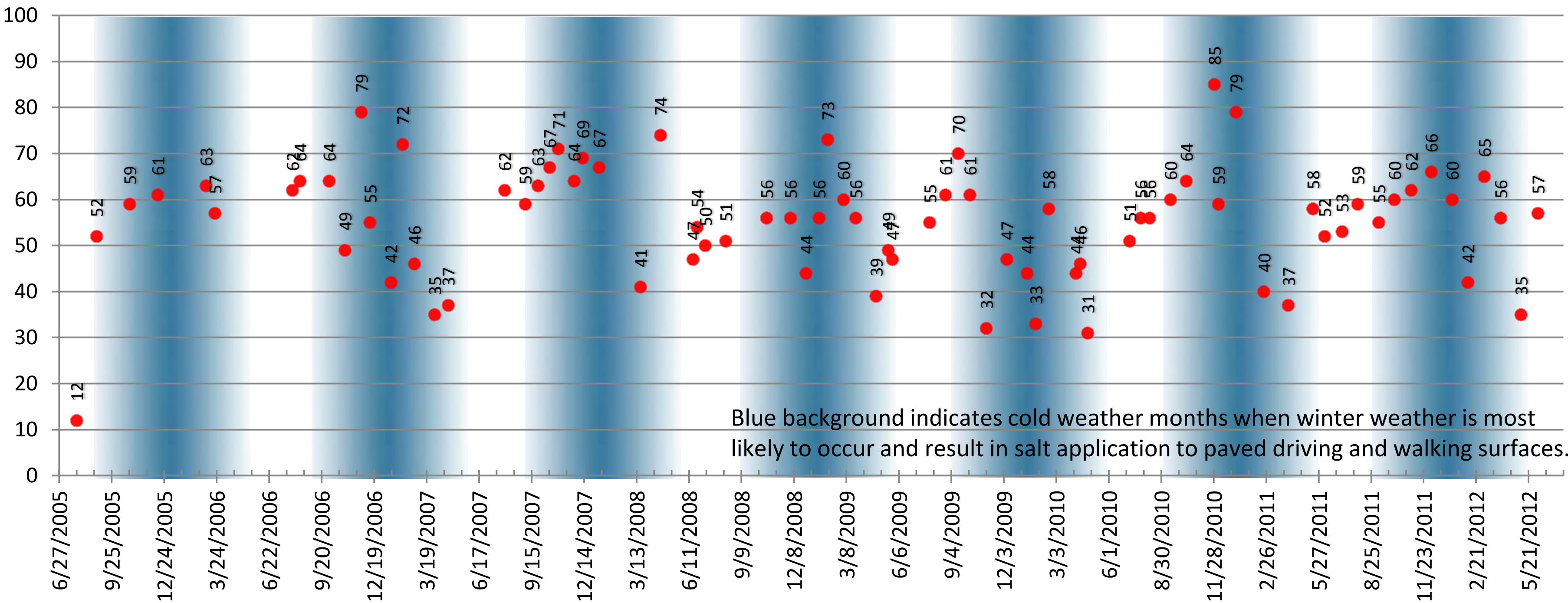
Stormwater Infrastructure

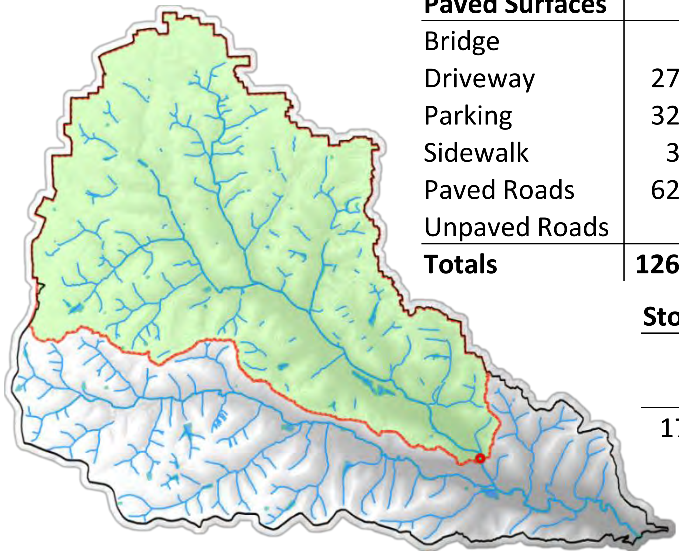
18	Stormwater Inlets
0.014	Stormwater Inlets per Acre
2078.6	Feet of Storm Sewers
1.6	Ft of Storm Sewers per Acre

The data from the Sontag Spring Branch seems to reflect the low amount of impervious surfaces that receive road salt in the winter. This sub-basin also has much less stormwater infrastructure than the Kiefer Spring Branch. This increases the likelihood that most chloride rich runoff will dissipate into the soils instead of being delivered directly to the stream channel. There is still a perceptible upswing during winter months, but the highest values are still well within the parameters of the water quality standard. If there is an increase in development in the Sontag Spring Branch we can expect to see an increase in the chloride load during winter months.

Sontag Spring Branch
Spring Branch @ New Ballwin Road

Chloride ● mg/l





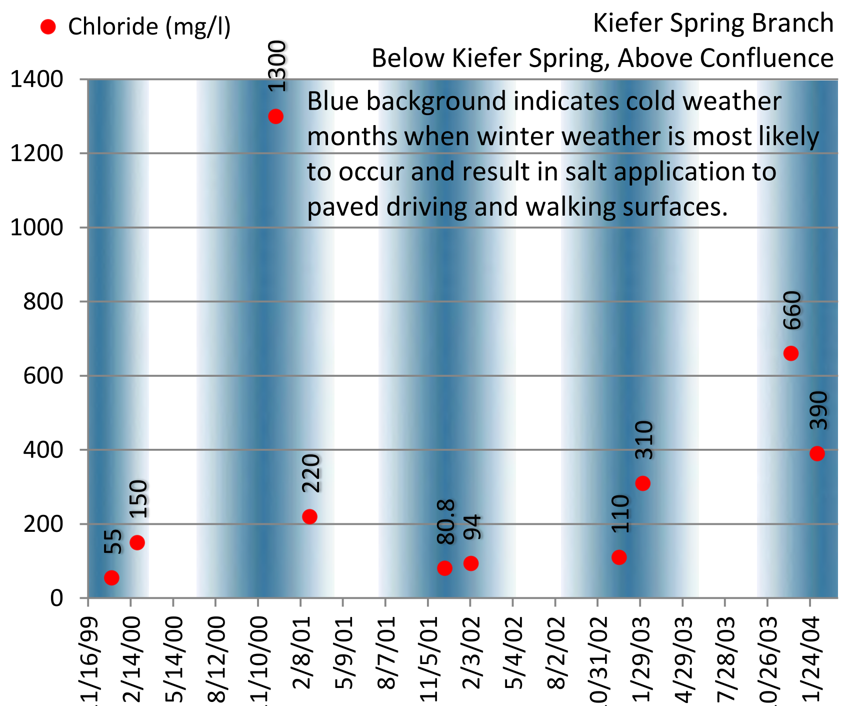
Paved Surfaces	Ft²	% of Total paved Surfaces	Ft² Per Acre of Catchment
Bridge	16285.8	0.106%	6.37
Driveway	2774774.0	18.084%	1085.17
Parking	3204510.0	20.885%	1253.23
Sidewalk	348403.2	2.271%	136.25
Paved Roads	6229497.5	40.600%	2436.25
Unpaved Roads	59306.3	0.387%	23.19
Totals	**12632776.7**	**82.333%**	**4940.47**

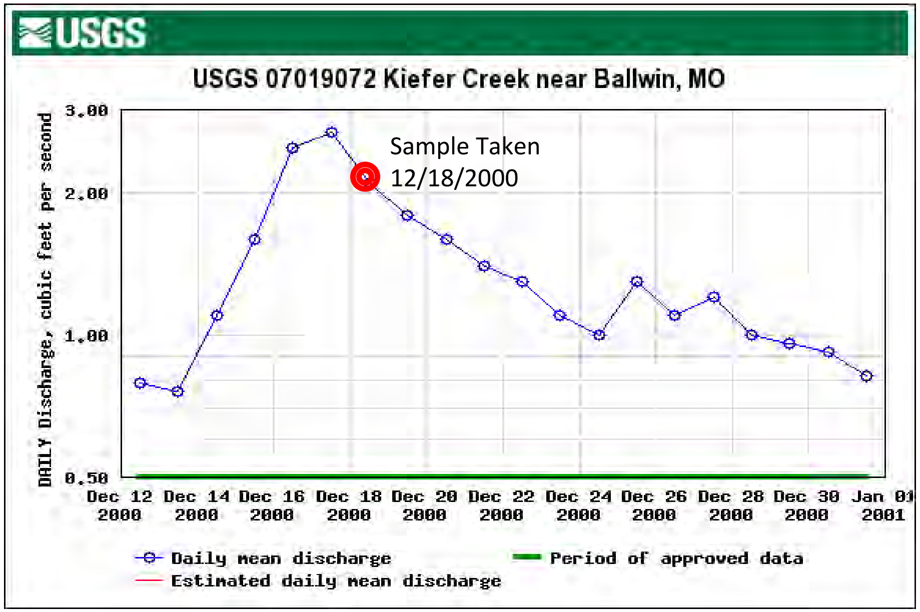
Stormwater Infrastructure

1368	Stormwater Inlets
0.54	Stormwater Inlets per Acre
172227.3	Feet of Storm Sewers
67.4	Ft of Storm Sewers per Acre

Unfortunately there is not more data from the Kiefer Spring Branch, however the data that was collected by the USGS between 1999 and 2004 shows a significant chloride issue. The USGS only measure chloride concentrations during winter months and managed to capture the highest levels measured in Kiefer Creek. We looked into the USGS hydrograph and NOAA weather data from December 12, 2000- the date of the highest chloride measurement. This sample captured the chloride runoff following significant winter weather and snow melt.

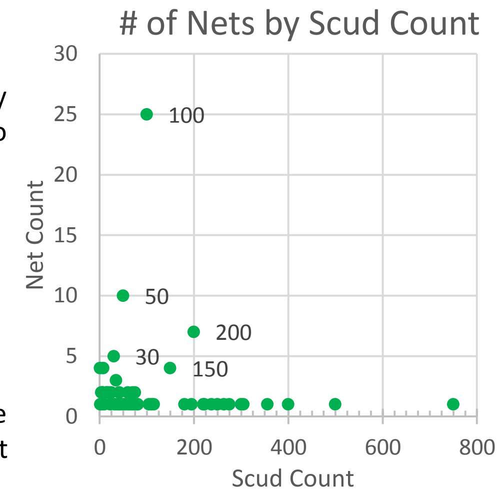
Date	Max Temp.	Min. Temp.	Ave. Temp.	Precip.	New Snow	Snow Depth
12/12/00	18	6	12	T	T	T
12/13/00	24	16	20	0.53	7.6	T
12/14/00	24	12	18	T	0.1	7
12/15/00	32	15	23.5	0.16	0.1	6
12/16/00	36	5	20.5	0.07	1.8	5
12/17/00	15	2	8.5	T	0.1	6
12/18/00	26	10	18	0.04	1	5

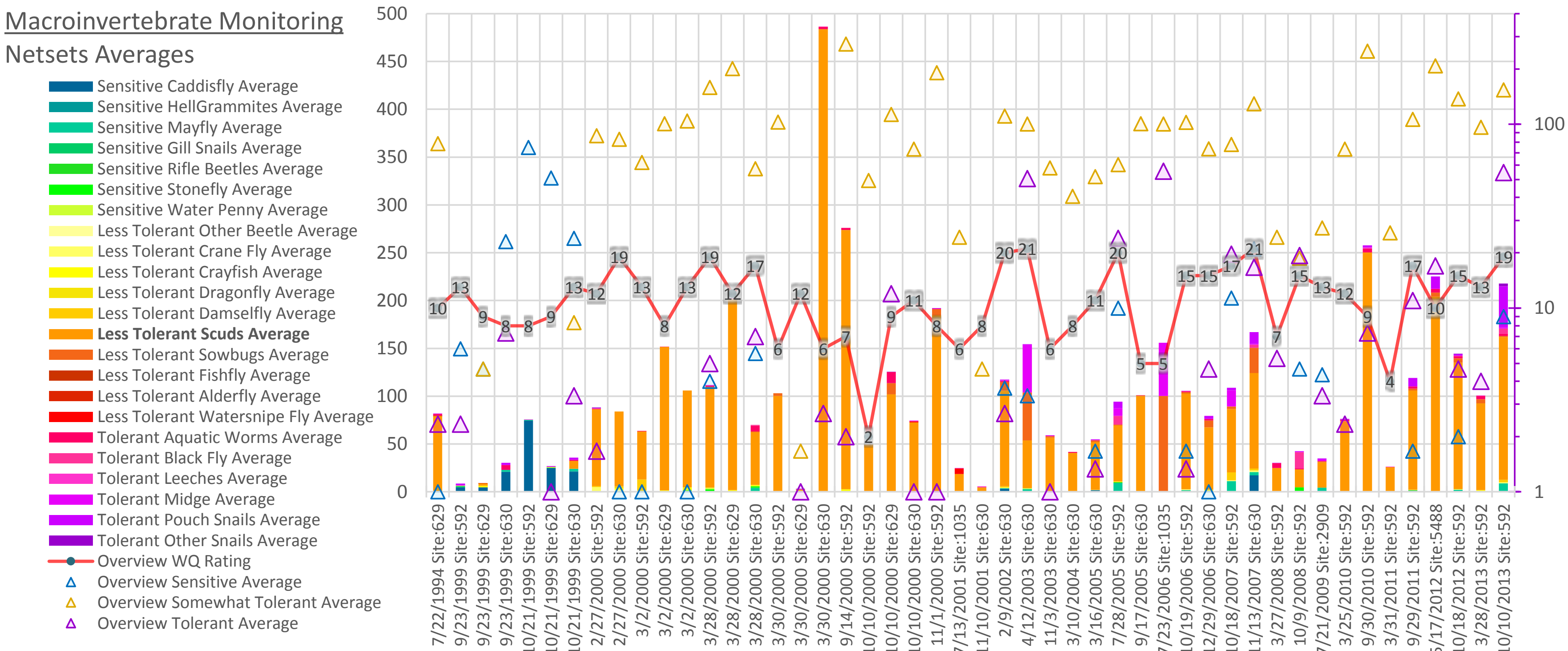




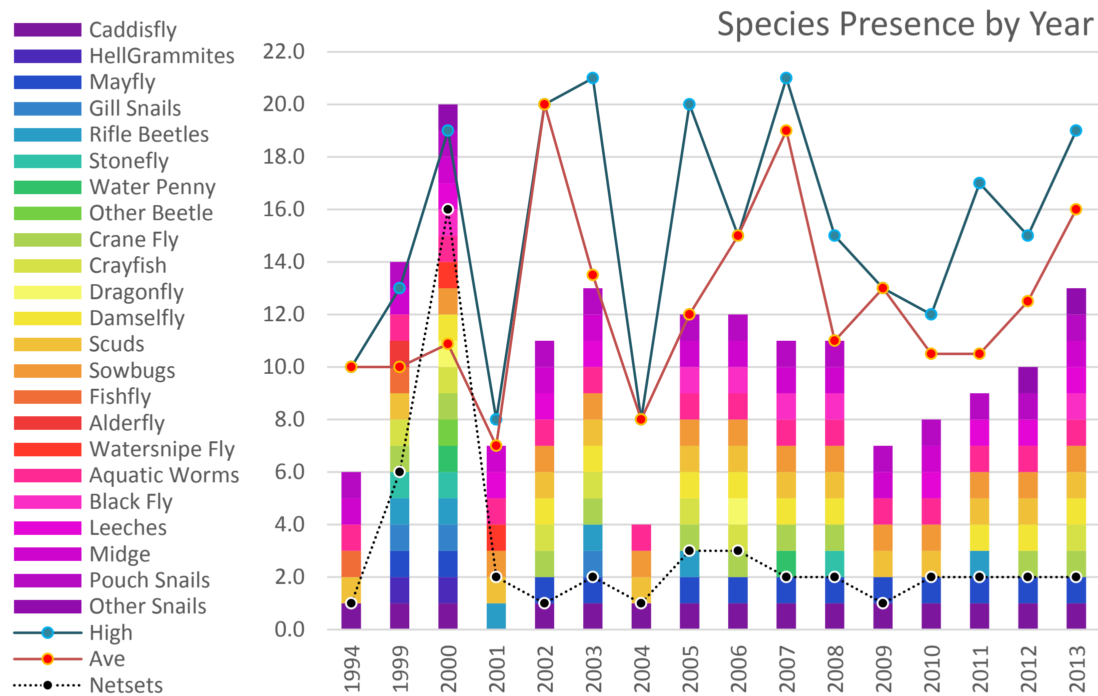
Since the chloride levels impair the aquatic life use it is important to take a look at the macro (macroinvertebrate) data that has been collected from the creek. Macros are the small insects that inhabit a healthy stream and serve play a key role in the ecosystem. Not only do they build the foundation for the stream food chain, they also tell us about the condition of an aquatic ecosystem. Some macros are highly sensitive to pollution while others are not, some are sensitive to certain pollutants more than others. Trained Missouri Stream Team Volunteers have used nets to collect 141 macro samples from Kiefer Creek from 6 different sites. In the map below we can see the general locations of each monitoring site. All of the locations selected are either within, or on the border of Castlewood State Park, where people can easily access perennial reaches of Kiefer Creek. Using a standardized methodology, volunteer monitors select a riffle in the streambed, then the streambed of the riffle is disturbed while a net placed directly downstream is used to collect the macros released by the disturbance. The macros are collected from the net and sorted by species, the number of each species is tallied up. The variety and pollution tolerance of the species collected is used to calculate an overall stream health score. This method of sampling the ecosystem is highly dependent on a wide range of variables. The disturbance of riffles could have a big impact on most of the monitoring sites due to the high number of recreational users in Castlewood State Park. The sampling date, and variation in seasonal and climatic conditions, can impact the prevalence of species only spend a part of their life-cycle in the stream during certain seasons. The expertise, skill and thoroughness of a Stream Team volunteer may vary significantly as well. In some cases, species may be misidentified or monitors may have selected poor sites for monitoring. On the map below we have included the stream health score from each monitoring event at each site. Kiefer Creek has an average stream health score of about 12 out of a possible 49, which is on the high end of poor. With about 15% impervious surface cover in the watershed and a high rate of human disturbance in the streambed in Castlewood State Park, it is not surprising that Kiefer is not host to a more robust aquatic ecosystem.

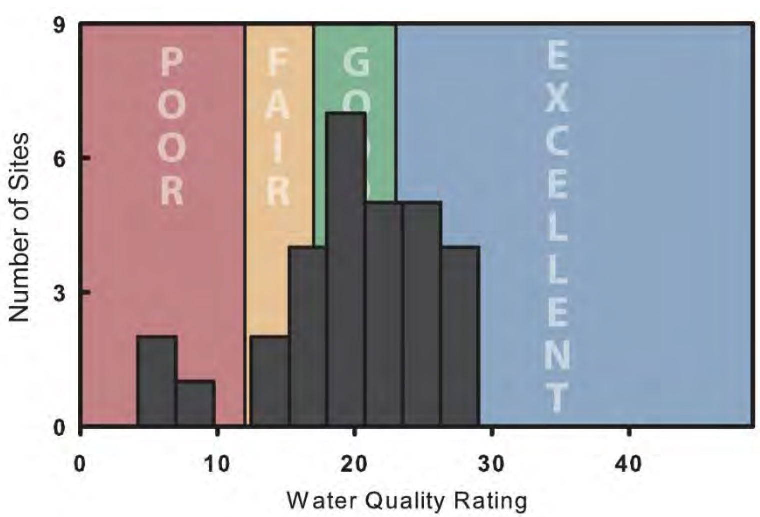
Below is a graph summarizing the results of their macroinvertebrate testing in 6 locations along Kiefer Creek. Plotted along the left y-axis are the average number of species collected per each netset monitoring event, this was calculated by dividing the number of each species collected in all nets in a netset by the number of nets collected, which is typically 3 – however there were four sets with 2 nets collected and one with 6. This graph also includes the averages for each category of tolerance, which was calculated by dividing the number of each species collected in all nets by the number of nets collected then adding up all species averages in each category. This table shows us that there is a downward trend in sensitive species, an upward trend in tolerant species and a steady increase in somewhat tolerant species. One particular species, the scud, is especially prominent in Kiefer Creek, while most other species only show up inconsistently and in small numbers. In the graph to the right It also appears that some monitors used different judgement regarding when to stop counting scuds, with 100 being a popular stopping point. In the graph below we are looking only at the presence of species in the creek. In this table we see that there seems to be a shift towards greater diversity due consistent presence of tolerant and somewhat tolerant species. The range of sensitive species in the stream seems to be declining slightly, with consistent appearances of only caddisflies and mayflies.

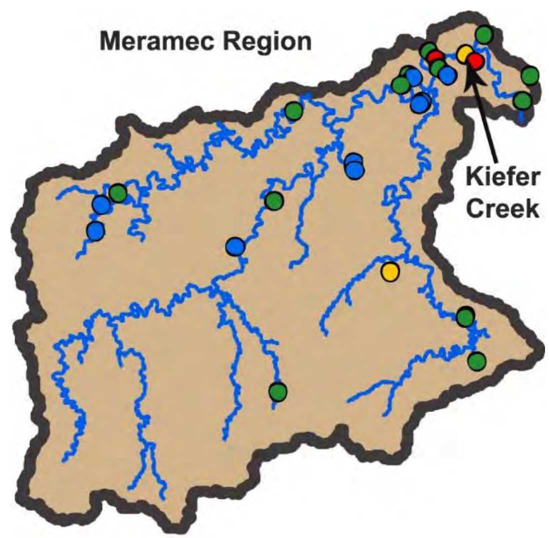




Net sets from 1999 and 2000 depict the highest level of diversity and the highest number of netsets, indication that there is a correlation between the species found each year and the number of net sets completed. A number of sensitive species found in 1999 and 2000 have not been found in the stream since, and the overall trend in diversity shows a stable presence of somewhat tolerant and tolerant species and a decline in sensitive species. On this chart we have also included two water quality ratings, the 'High' rating is the highest water quality rating found each year and the 'Average' is the average of water quality ratings from the netsets collected each year. The Missouri Stream Team Watershed Coalition has mined statewide monitoring data to give insight into the overall condition of our watershed. In their methodology they employ the 'High' method of determining the water quality rating. Below is a table and a map of the Meramec Region from the Missouri Stream Team Watershed Coalition's report on the 'State of Missouri's Streams: Summary of Invertebrate Data 1993 - 2000 .'



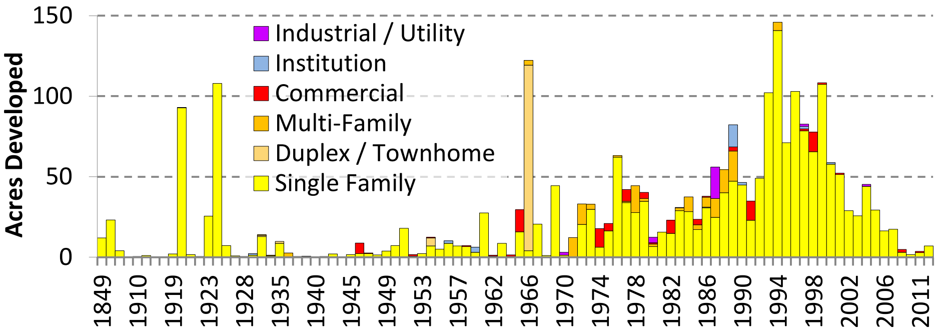


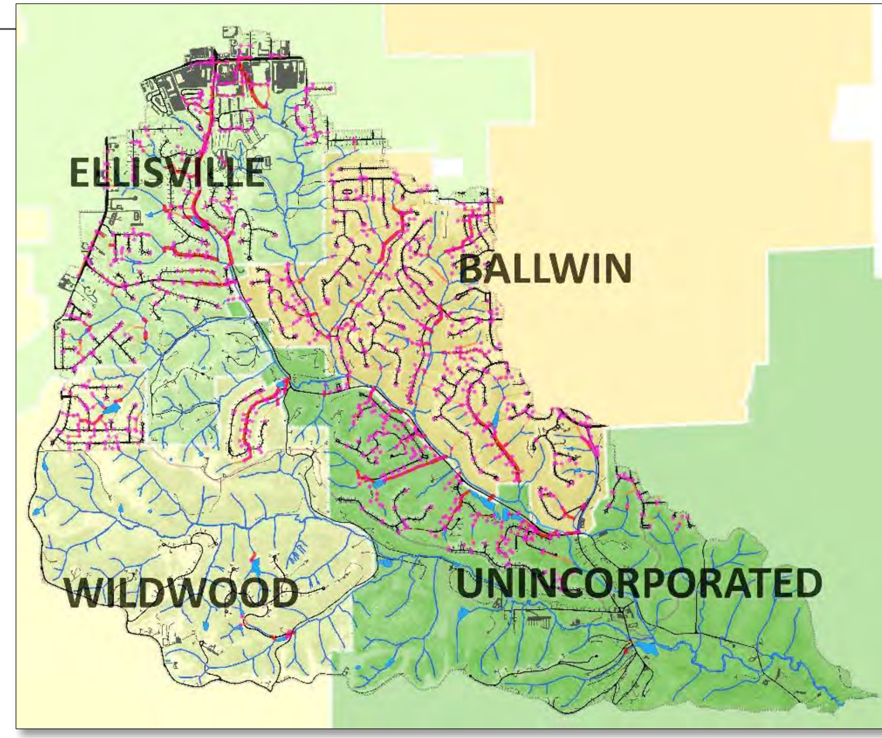


The Missouri Stream Team Watershed Coalition assessment of stream macroinvertebrate monitoring in the Meramec River Region helps us put the condition of Kiefer Creek into relative terms. Right now Kiefer Creek is in 'Fair' condition, while many other tributaries to the Meramec that are just upstream from Kiefer have 'Good' and 'Excellent' water quality ratings. If the chloride impairment in Kiefer Creek can be addressed through BMPs, Kiefer would likely become repopulated with more sensitive organisms from the Meramec and its nearby tributaries.

Chloride Assessment

In the Kiefer Creek Watershed driveways, roads and parking lots are the largest source of chloride in the watershed, comprising 90% of the paved surfaces that potentially receive road salt in response to winter weather. The majority of snow removal and deicing of roads and parking lots in the watershed is managed by local municipalities and contractors, while homeowners are generally in charge of their driveways and sidewalks. We can surmise that the aquatic life appear to be impacted by impervious area and the subsequent higher chloride load. In the table at the bottom of this page we have broken down the total impervious surfaces by municipality and type to estimate the allocation of chloride loading in terms that will be relevant to the adoption of BMPs.





Impervious Square Feet	WILDWOOD	% of Wildwood Imp.	% of Total NPS Chloride	UNINCORP-ORATED SLC	% of Uninc. SLC Imp.	% of Total NPS Chloride	ELLISVILLE	% of Ellisville Imp.	% of Total NPS Chloride	BALLWIN	% of Ballwin Imp.	% of Total NPS Chloride	Total	% of Total	% of Watershed	% of NPS Chloride
Main Buildings	1229367	33.0%	---	1771004	32.7%	---	3145319	29.5%	---	3522854	43.6%	---	9668544	36.0%	5.16%	---
Driveway	708220	19.0%	4.4%	1016219	18.8%	6.3%	1120674	10.5%	6.9%	843648	10.4%	5.2%	3688761	13.8%	1.97%	22.72%
Parking	59759	1.6%	0.4%	252081	4.7%	1.6%	2990808	28.0%	18.4%	133612	1.7%	0.8%	3436259	12.8%	1.84%	21.17%
Patio	231536	6.2%	---	254142	4.7%	---	369041	3.5%	---	531136	6.6%	---	1385855	5.2%	0.74%	---
Public Walks	125598	3.4%	0.8%	135841	2.5%	0.8%	388910	3.6%	2.4%	413781	5.1%	2.5%	1064129	4.0%	0.57%	6.55%
Sidewalk	63381	1.7%	0.4%	68945	1.3%	0.4%	146895	1.4%	0.9%	117097	1.4%	0.7%	396318	1.5%	0.21%	2.44%
Out Buildings	36458	1.0%	---	58891	1.1%	---	72498	0.7%	---	36437	0.5%	---	204284	0.8%	0.11%	---
Pool	31379	0.8%	---	23903	0.4%	---	50172	0.5%	---	24784	0.3%	---	130238	0.5%	0.07%	---
Recreation	---	---	---	4961	0.1%	---	54635	0.5%	---	15413	0.2%	---	75009	0.3%	0.04%	---
Bridge	457	0.0%	0.0%	17990	0.3%	0.1%	1547	0.0%	0.0%	9058	0.1%	0.1%	29051	0.1%	0.02%	0.18%
Tank	246	---	---	326	0.0%	---	50	0.0%	---	540	0.0%	---	1162	0.0%	0.00%	---
WaterTower	---	---	---	1064	0.0%	---	---	---	---	---	---	---	1064	0.0%	0.00%	---
Roads-Paved	1180799	31.7%	7.3%	1712143	31.6%	10.5%	2302950	21.6%	14.2%	2424063	30.0%	14.9%	7619955	28.4%	4.07%	46.94%
Roads-Unpaved	53423	1.4%	---	98646	1.8%	---	30371	0.3%	---	6393	0.1%	---	188833	0.7%	0.10%	---
Total Muni. Imp.	3720623			5416154			10673869			8078815			**27889462**	---	---	
% of Total Imp.	13.34%			19.42%			38.27%			28.97%			---	**100%**	---	
% of Watershed	1.99%			2.89%			5.70%			4.32%			---	---	**14.90%**	
Total NPS Chloride Surface	2138213		13.17%	3203218		19.73%	6951783		42.82%	3941258		24.28%	**16234473**	58.2%	**8.67%**	

Municipal Chloride Reduction and Reuse Strategies

Road safety is of the utmost importance so it is important to ensure that whatever solutions are implemented do not result in an increased risk to drivers. In the Kiefer Creek Watershed, roads and parking lots are likely the largest source of chloride in the watershed, comprising XX% of the paved surfaces that receive road salt in response to winter weather. Snow removal from roads and parking lots in the watershed is managed by both municipalities and private contractors, so it will be important to engage with both groups as well as the businesses that hire the private contractors to remove snow from drives and parking lots.

Convert to Liquid Brine Solution - Applying a brine solution consisting of 50% water and 50% chloride or other melting agent before snowfall, can prevent ice from bonding to road surfaces. When used properly this leads to a reduced need for salt to be applied to the roads, reducing both total salt used and the cost to municipalities and their residents. This practice is the best existing way to manage chloride runoff from the roads and parking lots in the Kiefer Creek Watershed and it is also very cost effective according to the many places that have implemented this technology.

Improve Application Efficiency - When rock salt is applied, efficient application can help reduce the amount of salt used and thus lower cost. Retrofitting municipal trucks with applicator regulators and not overfilling trucks are cost effective methods for reducing the amount of rock salt applied to roads. Lastly, training salt truck drivers regularly can also help improve application efficiency. This practice is not as effective as a conversion to brine systems, however it has a lower up-front cost to implement and could be a good halfway point for full implementation.

Cleanup and Reuse Excess Rock Salt - Once chloride has been applied to the driving surfaces of a watershed, it will eventuallly run off into the stream. By cleaning up excess road salt and reusing the salt that has already been applied in the watershed, we can reduce the total amount of salt used in the watershed, which is critical to reducing the chloride load that impairs aquatic life in Kiefer Creek. This is applicable to both homeowners and municipalities. Safety should be an important aspect of this procedure as any salt that has accumulated will have done so near a roadway.

Salt Storage - Storing the salt in an enclosed or covered facility can help municipalities and businesses from losing salt in a rain event or with snowmelt runoff. Allowing the salt to be directly exposed to rain can cause large amounts of the salt to be washed away directly into near by water bodies.

Chloride Runoff Recycling - The chloride runoff from large parking lots is one of the more substantial sources of chloride in the watershed. In theory you could build settling ponds designed to allow trucks with brine systems to refill with the already chloride rich runoff, thereby reusing a portion of the chloride and reducing the total amount applied in the watershed.

Improved Stormwater Infiltration **-** Any infiltrative stormwater BMP with a driving or walking surface catchment is likely to reduce the amount of salt reaching the stream channel quickly via surface runoff and storm sewers, although the salt will reach the stream eventually. Improved infiltration will help reduce the acute chloride load, though it may prolong chronic loading as the chloride slowly makes its way into the stream. For planted BMPs it is important to select salt tolerant plants where the BMP is likely to receive a substantial chloride load from snow removal practices such as a large commercial parking lot or road surface.

SHORT TERM (2015-2020) Engage with all municipalities and businesses and institutions with large paved areas to provide information about converting to liquid brine and improving application efficiency. Encourage cleanup and reuse of salt and appropriate salt storage, and engage with municipalities and property owners on the employment of stormwater BMPs and runoff recycling.
MEASUREABLE MILESTONE: All large scale stakeholders have been engaged, 1 of 4 municipal entities have implemented a brine system and the remaining municipalities have worked on improving application efficiency, one local contractor has begun offering brine as a service. Some effort is made to clean up excess salt, all road salt is being stored appropriately and those using or considering brine solution are also engaged in an evaluation of potential runoff recycling. Stormwater BMPs are promoted among municipalities and owners of large properties.
LOAD REDUCTION: 15% reduction in chloride load from municipalities, businesses and institutions.

Municipal Chloride Reduction and Reuse Strategies

MID TERM (2020-2025) Engage with all municipalities and businesses and institutions with large paved areas to provide information about converting to liquid brine and improving application efficiency. Encourage cleanup and reuse of salt and appropriate salt storage, and engage with municipalities and property owners on the employment of stormwater BMPs and runoff recycling.

MEASUREABLE MILESTONE:

All large scale stakeholders have been engaged, 2 of 4 municipal entities have implemented a brine system and the remaining municipalities have worked on improving application efficiency, two local contractors have begun offering brine as a service. Excess salt is cleaned up, all road salt is being stored appropriately and those using or brine solution are also engaged in runoff recycling. Infiltrative stormwater BMPs are being strategically implemented by municipalities and owners of large properties with chloride runoff considerations taken into account.

LOAD REDUCTION: 27.5% reduction in overall chloride load from municipalities, businesses and institutions and a 2% reduction in acute chloride levels due to improved infiltration.

LONG TERM (Post-2025) Engage with all municipalities and businesses and institutions with large paved areas to provide information about converting to liquid brine and improving application efficiency. Encourage cleanup and reuse of salt and appropriate salt storage, and engage with municipalities and property owners on the employment of stormwater BMPs and runoff recycling.

MEASUREABLE MILESTONE:

All large scale stakeholders have been engaged, all municipal entities have implemented a brine system and three local contractors have begun offering brine as a service. Excess salt is cleaned up, all road salt is being stored appropriately and those using or brine solution are also engaged in runoff recycling. infiltrative stormwater BMPs continue to be strategically implemented by municipalities and owners of large properties with chloride runoff considerations taken into account.

LOAD REDUCTION: 40% reduction in overall chloride load from municipalities, businesses and institutions and a 5% reduction in acute chloride levels due to improved infiltration.

PARTNERS: Through coordination among MSD and municipal public infrastructure partners in Ellisville, Ballwin, Wildwood and St. Louis County information, feedback and implementation guidance can be disseminated. The Kiefer Creek Watershed Group and East West Gateway Council can work on bringing all of the partners to the table and expanding the discussion to include the entire Lower Meramec Watershed and St. Louis Region, where chloride is a significant issue.

TECHNICAL AND FINANCIAL ASSISTANCE NEEDED

Technical Assistance: MSD and other local municipalities that have already implemented these practices can provide technical information and reporting on results from implantation. MoDOT may also be able to provide in-depth technical support.

Financial Assistance: Municipalities and contractions should be provided with short-term (3-5 year) loans to expedite implementation of brine systems, which will likely be paid off quickly in savings on chloride costs.

Sources of Funding: 319 Program, State, Local , Private, Matching from Partners and Participating Residents.

MONITORING: MSD already works with local municipalities to collect information on salt usage through the MS4 permitting program. MSD will continue to track and interpret this data to help guide implementation.

Homeowner Chloride Reduction and Reuse Strategies

Homeowner chloride management strategies are much the same as the municipal strategies however the outreach component is integrated into the CCCW program as a new module.

Homemade Brine Solution – Using a simple sprayer, a homeowner can mix and spray an effective brine solution and reduce their salt usage by 30%-50%. Distribution of brine DIY instructions and recipes should be conducted to encourage this practice.

Bird Seed for Traction – Often people utilize rock salt in order to improve traction, this can result in overuse of rock salt. Instead homeowners should use bird seed to provide traction, which is innocuous to the environment chemically and helps sustain local wildlife diversity.

Cleanup and Reuse Excess Rock Salt - Once chloride has been applied to the driving surfaces of a watershed, it will eventually be carried into the stream by rainfall. By cleaning up excess road salt and reusing the salt that has already been applied in the watershed, we can reduce the total amount of salt used in the watershed, which is critical to reducing the chloride load that impairs aquatic life in Kiefer Creek. Safety should be an important aspect of this procedure as any salt that has accumulated will have done so near a roadway.

Improved Stormwater Infiltration - Any infiltrative stormwater BMP with a driving or walking surface catchment is likely to reduce the amount of salt reaching the stream channel via surface runoff and storm sewers. For natural BMPs it is important to select more salt tolerant plants where the BMP is likely to receive salty runoff from driveways, roads and sidewalks.

SHORT TERM (2015-2020) Create and Launch the CCCW 'Hold the Salt' Outreach and Education Module

- Develop 'Hold the Salt Module' using CCCW framework
- Conduct outreach campaign via mailing campaign and public signage to explain the scope of problem and recognize early adopters.
- Give homeowners information on things that they can do NOW to begin to address the problem and provide them with additional information on the watershed to encourage participation in volunteer roles and adoption of additional BMPs.
- Home owners will pledge to participate in voluntary program.
- Utilize the 'Hold the Salt' module of a public outreach campaign. Module is part of an overall social marketing engagement strategy.

MEASUREABLE MILESTONE: 'Hold the Salt Campaign' is launched, 300 pledges from the public are gathered.
LOAD REDUCTION: 10% of chloride load from residential use of road salt

MID TERM (2020-2025) CCCW 'Hold the Salt' Campaign Continues
MEASUREABLE MILESTONE :'Hold the Salt Campaign' continues, 600 pledges from the public are gathered.
LOAD REDUCTION: 20% of chloride load from residential use of road salt

LONG TERM (Post-2025) CCCW 'Hold the Salt' Campaign Continues
MEASUREABLE MILESTONE: : 'Hold the Salt Campaign' continues, 900 pledges from the public are gathered.
LOAD REDUCTION: 30% of chloride load from residential use of road salt

PARTNERS: MSD, Municipalities and the Kiefer Creek Watershed Group can work together to support the outreach and education efforts of the CCCW program.

TECHNICAL AND FINANCIAL ASSISTANCE NEEDED
Sources of Funding: 319 Program, State, Local , Private, Matching from Partners and Participating Residents.

MONITORING: Kiefer Creek Watershed group and watershed volunteers can track the use of homeowner road salt BMPs through pledges and feedback from watershed residents.

Castlewood's Kiefer Creek
'Wonderfully Wadable by 2020 for our Future Generations'
'Create an opportunity for people to do something positive.'
– Chad Pregracke, founder of Living Lands and Water, LLC
'Non-Point Source Pollution is a people problem."
– David Wilson, East-West Gateway Council of Governments
'Begin with Behavior -- not awareness, not attitude, not education. Decide what you want your audience to do and build your whole message around that'
– Eric Eckl, founder of Water Words That Work, LLC
'In God we trust, all others must bring data.'
– W. Edwards Deming, management consultant EPA

Action Steps - **Public Actions to reduce harmful in-stream Bacteria Individual landowners and residents in the watershed can be motivated to take specific actions that can have a measurable impact on water quality**
The Kiefer Creek plan begins with public involvement, since increased public actions in the watershed will address all of the following sources of bacteria and chloride derived from private properties.
1. Pet Waste
2. Septic Systems
3. Healthy Lawns
4. Native Plantings
5. Horse Waste
6. Road Salt
The campaign will be focused on measurable behavior change by individuals who live in the watershed. In order to drive participation we will deploy a public-facing water quality dashboard. The dashboard will be populated from a continuous water-quality sonde, perh aps co-located with MSD's existing Kiefer Creek gage above Kiefer's Spring Creek Branch. The dashboard will supply the 'data proof' for people to trust that there is an immediate problem that requires action.

Rapid transition of this type of 'local' water data to 'local' decision-making is a concept that the National Science Foundation supports, and we believe that in the Kiefer watershed it will be an effective behavior change campaign. Providing timely and 'actionable' data will be a significant motivator in engaging the residents and user community of Kiefer Creek watershed and Castlewood State Park. The dashboard is primarily intended to drive measurable behavior change on watershed BMPs and to identify and engage early adopters. It is an information and education component used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures.

The goal of the Kiefer dashboard is to drive individuals to an existing online platform. That online platform is also in production, and is ready for re-use in Kiefer for a small fraction of its development cost. We will utilize an existing online platform, Clear Choices Clean Water (CCCW) (http://www.clearchoicescleanwater.org/) which will be customized for the Kiefer Creek community. The platform is based on Responsive Web Design, and will be fully personalized for Kiefer, using an administrator role. CCCW is a turn-key product in production. CCCW features a suite of social marketing best practices and related water-quality pledge modules, with auditable metrics accepted by the EPA to satisfy 319 requirements to gauge effectiveness. Reports are already formatted and with the level of detail required by EPA. CCCW is flexible over a broad range of platforms with a unified approach to internet marketing and search engine optimization. Eric Eckl, founder of Water Words That Work, LLC http://www.waterwordsthatwork.com/home described the CCCW site as one of the best that he'd ever seen, based on his review of the messaging, methodology, implementation and the Google Analytics data on site visitor behaviors. The representation of water data would be integrated as follows:
1. Create local Kiefer watershed resident (approx. 11,000) and Castlewood State Park user (annual visits 500K) awareness of current Kiefer Creek water quality conditions via a water-quality dashboard. Possibly use digital billboards in addition to online platforms.
2. Get public to 'pledge' behavior changes related to water-quality, using a specific 'Clear Choices, Clean Water for Castlewood's Kiefer Creek' online campaign site.
3. Site would be tailored to Kiefer/Castlewood community, including pledge module content, verbiage and images.

4. Create pledge campaigns of particular relevance to watershed.
5. GIS mapping will focus on Kiefer Watershed boundaries and sort pledges by Kiefer watershed residents/businesses and pledges outside Kiefer. Mapping of supporters contributes to engagement.
6. Measure success of dashboard and campaign by number of pledges and the ability to engage the 'pledgers' in watershed issues. The core CCCW project has been up and running in Indiana for 5 years, and is used by many MS4s in Indiana. It has been consistently supported by the EPA and the Indiana Department of Environmental Management.
7. Ultimately, use the lessons learned in Kiefer demonstration site elsewhere in the State of MO, possibly in conjunction with the Missouri Department of Natural Resource's 'Our Missouri Waters' watershed-based initiative.

The CCCW platform already includes pledge modules for four of the BMPs identified in the draft Kiefer Nine Element Plan. Other modules can be created at a reasonable cost.
1. Pet Waste - COMPLETE
2. Septic Systems - COMPLETE
3. Healthy Lawns - COMPLETE
4. Native Plantings – COMPLETE
5. Children's Pledge Program – PENDING
6. Horse Owners – TBD
7. Hold the Salt – TBD

The CCCW platform also includes the two following modules:
1. Water Conservation. This module was funded by Indiana-America Water and went live last month (March, 2015).
2. Volunteer Signup: This robust module was funded by Indianapolis-area MS4s. It went live in conjunction with National Volunteer Week of April 12-18, 2015. This volunteer signup module will have great promise for engaging the Kiefer community.

Kiefer Creek Watershed Group

The Kiefer Watershed Group will be organized as a project of America's Confluence, Inc. America's Confluence, Inc. is a 501(c)(3) charitable organization. Warren Grace is the Executive Director. The Kiefer Watershed Group will assume leadership for the successful implementation of the Kiefer Watershed Plan. The Missouri Coalition for the Environment has expressed to the Kiefer Watershed Group that they will not take an active role of any kind. The Kiefer Watershed Group intends to work with the Missouri Department of Natural Resources and other Agencies to create an approved watershed plan. The Kiefer Watershed Group will assume the key liaison role for the Kiefer Watershed Plan. Kiefer Watershed Group will implement the watershed plan. The Kiefer Watershed Group will meet on a quarterly basis to review implementation strategies and challenges. Warren Grace will lead the meetings.

Implementation Cost:
1. Cost to implement Clear Choices Clean Water for Kiefer Creek would be approximately $10,000 for a two year commitment. Promotional materials would be an additional cost, although cost is greatly reduced. Affiliates have access to a cache of multimedia assets and a robust portfolio of social media resources.
2.Cost to implement sonde and dashboard is dependent on possible partnerships with USGS, MSD, +Pool and other entities. Hardware cost for sonde and supporting sonde hardware is approximately $5,000. There are a variety of sensors that can be used as accepted surrogates for pollutant loads. Staff time estimate is approximately $5,000

Implementation Timeframe: Project could go-live Q3 CY 2015.

A second step is to address the public actions that can reduce chloride pollution. A similar public engagement campaign, called "hold the salt' can be created for the Kiefer residential and business community. An information and education component used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.' – from the EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters. Our dashboard template is in production already by the +Pool initiative in New York City. It is displayed on digital billboards in the NYC area, and on mobile devices and the internet. http://pluspool.org/floatlab/. The data for the +Pool dashboard is fed from a continuous water quality sonde in New York Harbor operated by +Pool. Bacteria information is updated manually, as available from lab results from grab samples.

Stream Channel and Riparian Buffers– Restoring stream and flow buffers will help to filter and process the manure that is deposited in pastures and animal waste in back yards. Unprotected riparian areas are prone to high levels of erosion in Kiefer Creek, which can cause significant degradation of the aquatic habitat in the stream channel. There are also un-vegetated areas in some of the pastures that may be erosive and contribute to sediment loading due to high horse traffic. Shifting trails over time to distribute impacts, planting more resilient native grasses, and rebuilding degraded areas would all help to reduce erosion. Reducing erosion and sediment loading will reduce the amount of bacteria being carried to the stream because bacteria is much more mobile when it can bind to sediment particles. Excluding horses from travelling along stream banks altogether would also be a good practice to reduce the amount of erosion and bacteria entering the stream.

The Nature Conservancy expects to complete a stream stability assessment and propose restoration actions for the Keifer Creek riparian corridor within the next year. These practices can, also be implemented throughout the watershed, even watershed residents without pets and horses can implement these practices to help reduce bacteria loading from wildlife and outdoor cats.

SHORT TERM (2015-2020) TNC completes stream stability study and proposes stream channel and riparian restoration. Restoration project partnerships established with landowners and on public lands.
MEASUREABLE MILESTONE: Identify priority restoration sites in the watershed, secure the necessary funding and resources and initiate restoration projects.
LOAD REDUCTION:

MID TERM (2020-2025) . Restoration project partnerships established with landowners and on public lands.
MEASUREABLE MILESTONE : Stream Bank and Riparian Restoration Projects continue to be funded and implemented in the watershed.
LOAD REDUCTION:

LONG TERM (Post-2025) . Restoration project partnerships established with landowners and on public lands.
MEASUREABLE MILESTONE: Stream Bank and Riparian Restoration Projects continue to be funded and implemented in the watershed.
LOAD REDUCTION: 30% of chloride load from residential use of road salt

PARTNERS: TNC is the lead partner on this BMP in terms of providing technical and financial support, while MDNR, MDC and the Wildlife Rescue Center can all contribute to this project by providing areas within the watershed that are both public and in need of restoration.

TECHNICAL AND FINANCIAL ASSISTANCE NEEDED
Technical Assistance: The Nature Conservancy is already providing high level restoration assessment and remediate study.
Financial Assistance:
Sources of Funding: 319 Program, State, Local , Private, Matching from Partners and Participating Residents.

MONITORING: Kiefer Creek Watershed group and watershed volunteers can track the use of native landscaping through pledges, participation in the Bring Conservation Home Program and feedback from watershed residents.

Home Landscape Habitat Restoration – In undisturbed ecosystems, animal waste is digested and absorbed as a beneficial nutrient for the flora and fauna of the watershed. This is shown by the relatively undeveloped reaches of streams in the Ozarks that support a vibrant wildlife population without excessive bacteria in the waterways. When animal waste is deposited on an impervious surface or a turf lawn, runoff will carry the waste directly to the stormwater management system and subsequently, the local waterway. When natural habitat increases, so does the likelihood of animal waste being naturally digested. By converting mown lawns back to the native forests, wildlife contributions of bacteria to Kiefer Creek will be reduced, as will bacteria loading from domestic animals. This is also a great opportunity to link up forest fragments to create larger contiguous habitats which is essential to restoring biodiversity to the watershed and creating stronger forest ecosystems. Many of the backyards in the Kiefer Creek Watershed back up to forests, by adding site appropriate native plantings to the forest edge and infiltrative native planting beds in low spots the bacteria runoff from pet and wildlife waste in yards has a greater chance of being intercepted and naturally disinfected instead of contributing to the non-point source bacteria load. Through programs like St. Louis Audubon's 'Bring Conservation Home Program watershed residents and horse owners can get professional advice on how to proceed with landscape restoration implementation. Through the CCCW Native Landscape Module

SHORT TERM (2015-2020) Launch the CCCW Native Landscape Outreach and Education Module

- Conduct outreach campaign via mailing campaign and public signage to explain the scope of problem and recognize early adopters.
- Give homeowners information on things that they can do NOW to begin to address the problem and provide them with additional information on the watershed to encourage participation in volunteer roles and adoption of additional BMPs.
- Home owners will pledge to participate in voluntary program.
- Utilize the Native Landscape module of a public outreach campaign. Module is part of an overall social marketing engagement strategy.

MEASUREABLE MILESTONE: Native Landscape module is launched, 300 pledges from the public are gathered.
LOAD REDUCTION: 10 acres of underutilized landscape area converted to native plants.

MID TERM (2020-2025) CCCW Native Landscape Campaign Continues
MEASUREABLE MILESTONE :Native Landscape outreach continues, 600 pledges from the public are gathered.
LOAD REDUCTION: 25 acres of underutilized landscape area converted to native plants.

LONG TERM (Post-2025) CCCW Native Landscape Campaign Continues
MEASUREABLE MILESTONE: : Native Landscape outreach continues, 900 pledges from the public are gathered.
LOAD REDUCTION: 50 acres of underutilized landscape area converted to native plants.

PARTNERS: MSD, Municipalities and the Kiefer Creek Watershed Group can work together to support the outreach and education efforts of the CCCW program.

TECHNICAL AND FINANCIAL ASSISTANCE NEEDED
Technical and Financial Assistance: Landscaping can cost a lot or a little depending on the approach taken. Native tree and shrub saplings called 'whips' can be ordered from MDC for as little as 10 cents each, or one can spend more than $100 on one large tree. Perennial native grasses, wildflowers and other herbaceous plant materials can be acquired from any number of local nurseries or planted from seed. Once established, most native species can be divided and distributed to expand restoration areas at no cost beyond the time spent. As the area of native plantings and expanded forests increases the costs of lawn maintenance will decrease, potentially to the point that native plantings provide more savings than the initial cost of purchasing and installing the plants.
Sources of Funding: 319 Program, State, Local , Private, Matching from Partners and Participating Residents.

MONITORING: Kiefer Creek Watershed group and watershed volunteers can track the use of native landscaping through pledges, participation in the Bring Conservation Home Program and feedback from watershed residents.

Stormwater Management and Habitat Restoration

The long term survival of Kiefer Creek as an aquatic habitat is threatened by the increase in stormwater runoff due to increasing impervious surfaces. Stormwater management is complex, and various portions of the infrastructure in Kiefer Creek have been built at different times using different methods. In some newer developments such as the recreation center in Bluebird Park, practices such as parking lot bio-swales have already been implemented. In many other areas there is little consideration given to the downstream impacts of increased stormwater runoff. The increase in runoff has contributed to erosion along the stream channel and exacerbates flood levels. We propose that stormwater management is improved in the watershed by having the Kiefer Creek Watershed Group work with MSD, municipalities, developers and property owners to make improvements to the stormwater system in Kiefer Creek. These partners would:

- Work with property owners, municipalities, public works to implement recommended BMPs
- Identify stormwater management opportunity areas where a practice can be implemented to improve hydrologic balance
- Review development proposals and propose improved stormwater management approaches
- Use innovative approaches to reduce the cost of implementation per gallon of stormwater management.
- Identify unused impervious surfaces that can be reverted to an infiltrative natural landscape, such as the former dioxin superfund cleanup soil storage site that is currently owned by MSD.
- Map out locations of stormwater inlets for 'adopt an inlet' program. We would like to have an 'adopt a stormwater inlet' module within Clear Choices Clean Water, starting with what's already put together in CCCW. We would like Kiefer residents to see what inlets have been already adopted, and which are still available.

<u>SHORT TERM (2015-2020)</u> – MSD, East West Gateway Council and MDNR engage with municipalities, subdivisions and watershed stakeholders to identify opportunities to improve stormwater management in the watershed with a special emphasis on LID and plant based BMPs. Funding for high priority strategic stormwater management practices is secured and being used for implementation.

<u>MEASUREABLE MILESTONE</u>: Identify priority stormwater management sites in the watershed, secure the necessary funding and resources and initiate stormwater management projects.

<u>LOAD REDUCTION</u>: 1.5% reduction in stormwater runoff from impervious surfaces.

<u>MID TERM (2020-2025)</u> . Stormwater management projects and partnerships continue to be established with a broad range of watershed land owners.

<u>MEASUREABLE MILESTONE</u> :Identify priority stormwater management sites in the watershed, secure the necessary funding and resources and initiate stormwater management projects.

<u>LOAD REDUCTION:</u> 3% reduction in stormwater runoff from impervious surfaces

<u>LONG TERM (Post-2025)</u> Stormwater management projects and partnerships continue to be established with a broad range of watershed land owners.

<u>MEASUREABLE MILESTONE</u> :Identify priority stormwater management sites in the watershed, secure the necessary funding and resources and initiate stormwater management projects.

<u>LOAD REDUCTION:</u> 4.5% reduction in stormwater runoff from impervious surfaces

<u>PARTNERS</u>: MSD, East West Gateway Council, Municipal Partners, Developers and Watershed Landowners will all need to be engaged in raising the bar for stormwater management in Kiefer Creek.

<u>TECHNICAL AND FINANCIAL ASSISTANCE NEEDED</u>

<u>Technical Assistance</u>: MSD and municipal engineers will have the technical expertise to evaluate stormwater management practices, and can gather additional information from the EPA and MDNR on stormwater management practices that have been the most successful in other watersheds.

<u>Sources of Funding</u>: 319 Program, State, Local , Private, Matching from Partners and Participating Residents.

<u>MONITORING</u>: MSD already keeps track of stormwater BMPs and we expect this monitoring to continue. The USGS gauging station can also be used to track reductions in peak stream flow and elevated baseeflow indicative of improved infiltration of stormwater runoff.

Reforestation, Invasive Eradication and Demonstration Projects

Reforestation - Forests are the most perfectly designed best management practice for the Kiefer Creek Watershed. Healthy forests absorb rainfall, cool the air, filter out particulate pollution, sequester carbon and provide an excellent habitat for native wildlife. Historically the natural landscape of the watershed would consist of primarily oak/hickory forest areas with patches of rocky upland grass and shrub glades, with wetlands in low areas along the stream channel and in wet areas around springs. The native plant communities in these areas played a vital role in supporting the diverse and robust populations of native wildlife, while also holding and building soils and buffering, filtering and infiltrating rainfall. As forests are removed and replaced with compacted lawns, pavement and buildings the watershed loses its ability to buffer, filter, infiltrate and buffer rainfall.

Conveniently, trees are also very inexpensive or even free and only require somewhere to be planted, someone to plant them and a little water during dry periods for the first year or two. During the watershed planning process we held a couple of tree planting days at Castlewood State Park and they were very successful, drawing over 200 volunteers. With a relatively small investment and effective partnerships it would be easy to plant at least 1000 trees per year in the Kiefer Creek Watershed. The USDA NRCS recommends up to 1000 trees per acre due to high mortality (60%-70%) when planting whips (small saplings consisting of a branch with a root). Planting along riparian zones and flow paths should be the first priority, and public or semi-public lands provide many opportunities in the watershed to create demonstration planting projects to promote this practice.

Invasive Eradication - Another aspect of restoration that is necessary to consider and make progress on through the watershed plan is the control and eradication of invasive species,. In the Kiefer Creek Watershed the most problematic invasive species is Japanese Bush Honeysuckle. The dominant presence of this invasive species in the understory of many forested areas of the watershed is troubling, this blanket of honeysuckle is choking out the future generations of native trees and upsetting the natural succession of the forests. Efforts have already been undertaken in some parks and institutional spaces in the watershed and this effort should continue. Once honeysuckle has been eradicated from an area native white and black oak, hickory saplings should be planted to jumpstart the forest succession, along with a mix of appropriate native flowers, shrubs and trees best suited for the for the forest understory.

Demonstration Projects – One of the best ways to encourage watershed residents to restore native plant communities and plant based stormwater management approaches is to implement demonstration projects. Implementation of demonstration can be achieved, at least in part, through volunteer work days which provide a great opportunity to educate and train watershed residents on the value of native plants, proper planning methods and native plant species. In the watershed we have identified four sites that offer excellent opportunities for the implementation of demonstration projects:

- Castlewood State Park – Castlewood is one of the most popular parks in the St. Louis Region and it straddles both sides of the main branch of Kiefer Creek all the way to the confluence with the Meramec River. We have already conducted volunteer restoration and invasive removal in some priority areas and it would be good to continue to work with MDNR and the park supervisor on this reforestation and restoration effort. Castlewood also offers opportunities to implement stormwater management practices such as rain gardens and bio-swales to address runoff from impervious surfaces.
- The Wildlife Rescue Center – The WRC has been a strong partner through the watershed planning process and would like to continue to be a part of the project as we move into the implementation phase. The WRC is located just upstream from Castlewood and abuts the confluence of the Kiefer and Sontags branches of the creek, straddles both sides of the Sontags branch and includes a pond. We have discussed restoration projects on their site and found great interest from partners with the Missouri Master Naturalists, The Nature Conservancy and the Urban Waters Initiative. On their site there is the potential to demonstrate how to deal with erosion issues, restore riparian corridors, enhance pond water quality with buffers, convert mown lawn to native planting beds and install rain gardens and other stormwater practices around a building that is similar in size to a typical home in the watershed.

Reforestation, Invasive Eradication and Demonstration Projects

- Bluebird Park – Ellisville's Bluebird Park, in the northern end of the Kiefer spring subshed, is the only city park within the watershed. The park contains a mix of facilities, parking, lawn areas, forests and trails and is highly used by the local residents. The Open Space Council has long been involved in invasive eradication in Bluebird Park and we encourage this activity to continue and be enhanced with some targeted riparian restoration, understory plantings and potentially the conversion of some lawn areas back to forest. Bluebird Park is also the site of some excellent bio-swales that are used to manage stormwater from their parking lot, this example can be used to encourage other developers, landowners and businesses with significant impervious surfaces to consider a similar approach
- Klamberg Woods – The Klamberg Woods is a small conservation area within the upper reaches of the Kiefer branch of the watershed that is adjacent to Bluebird Park, and is owned by the Missouri Department of Conservation. This is a very good area to engage in invasive eradication and long-term forest management practices. Much of the land in the Kiefer Creek Watershed is held in large parcels with significant forested areas, Klamberg could serve as a training ground and demonstration area for the implementation of effective invasive eradication practices and successional reforestation.

<u>SHORT TERM (2015-2020)</u> – Work with partners to continue and enhance reforestation and invasive eradication efforts while developing funding and resources to implement demonstration projects within the watershed.

<u>MEASUREABLE MILESTONE</u>: Plant 5000 trees (1000/yr), preferably in deforested riparian zones. Eradicate honeysuckle from 10 acres of forested area. Secure funding for, and begin implementation of demonstration projects at Castlewood State Park and the Wildlife Rescue Center.

<u>LOAD REDUCTION</u>: Reduces current and future stormwater loading, reduces erosion, improves filtration of runoff, creates habitat for wildlife.

<u>MID TERM (2020-2025)</u> – Work with partners to continue and enhance reforestation and invasive eradication efforts while developing funding and resources to implement demonstration projects within the watershed.

<u>MEASUREABLE MILESTONE</u> :Plant 5000 trees (1000/yr), preferably in deforested riparian zones. Eradicate honeysuckle from 10 acres of forested area. Secure funding for, and begin implementation of demonstration projects at Bluebird Park and the Klamberg Woods, continue implementation and maintenance of demonstration projects at the Wildlife Rescue Center and Castlewood State Park.

<u>LOAD REDUCTION:</u> Reduces current and future stormwater loading, reduces erosion, improves filtration of runoff, creates habitat for wildlife.

<u>LONG TERM (Post-2025)</u> Work with partners to continue and enhance reforestation and invasive eradication efforts while developing funding and resources to maintain and enhance demonstration projects within the watershed.

<u>MEASUREABLE MILESTONE</u> :Plant 5000 trees (1000/yr), preferably in deforested riparian zones. Eradicate honeysuckle from 10 acres of forested area. Continue implementation and maintenance of demonstration projects at Bluebird Park, the Klamberg Woods, the Wildlife Rescue Center and Castlewood State Park.

<u>LOAD REDUCTION:</u> Reduces current and future stormwater loading, reduces erosion, improves filtration of runoff, creates habitat for wildlife.

<u>PARTNERS</u>: MDNR, the Wildlife Rescue Center, MDC, the City of Ellisville, Missouri Master Naturalists, St. Louis Audubon, the Open Space Council and the Kiefer Creek Watershed Group can develop projects, recruit volunteers and implement projects.

<u>TECHNICAL AND FINANCIAL ASSISTANCE NEEDED</u>

<u>Technical Assistance</u>: MDNR, MDC, St. Louis Audubon and the Missouri Master Naturalists are all highly skilled at these types of projects.

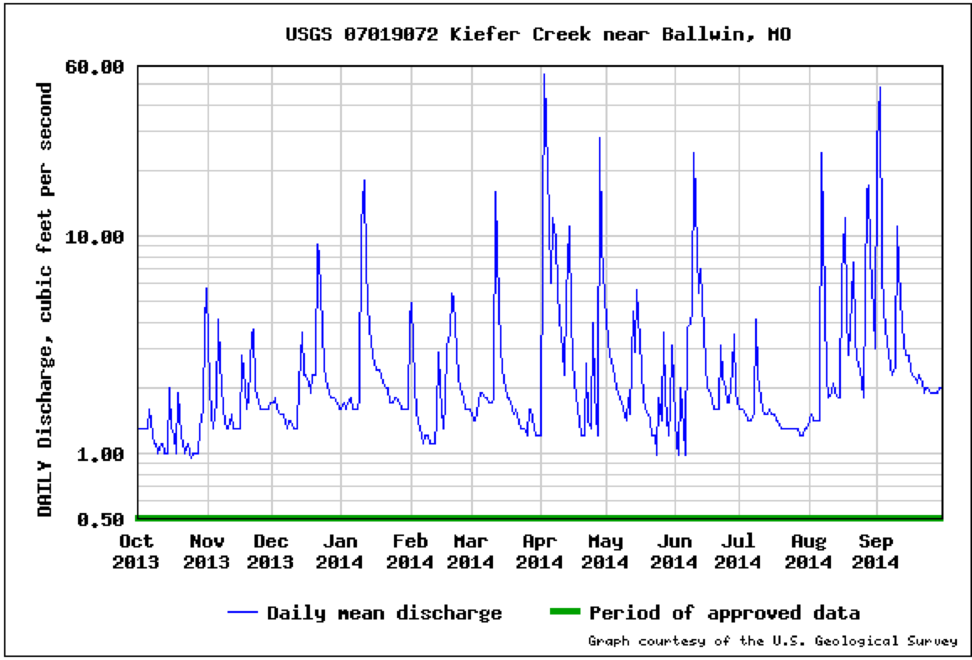
<u>Sources of Funding</u>: 319 Program, State, Local , Private, Matching from Partners and Participating Residents.

<u>MONITORING</u>: Project partners can track their progress and report on their achievements through participation in the Kiefer Creek Watershed Group.

Monitoring Strategy

In order to keep track of the bacteria loading in Kiefer Creek going forward it will be necessary to continue and enhance bacterial monitoring of the Creek. MSD will continue to collect samples as part of their regional water quality monitoring program, these samples are collected according to a pre-determined schedule. In addition, MDNR may conduct monitoring as part of the TMDL implementation process. The St. Louis County Health Department could also become a partner in the monitoring effort. Monitoring should continue to be collected from the established sampling locations in both sub-basins, and on the main stem of the creek in Castlewood State Park. The analysis of the water quality data from Kiefer Creek shows that the 'achievement' of water quality standards is highly dependent upon when the samples are collected. It is important that the data be collected during flows that are representative of the range of hydrologic conditions in the watershed.

To best understand the risk for recreational users it would be most beneficial to collect samples during the times when recreational users are most likely to be exposed to elevated bacteria. It is unlikely that recreational users are going to be in the creek during high-flow conditions, which typically occur during, and within the 6 hours following, significant rainfall. Elevated bacteria levels could last for as long as a week based on our assessment of the correlation between rainfall and bacteria concentrations. Annually, multiple samples should be collected within 5 days of significant rain events during the recreational season in order to better understand and track the threat to recreational users.



Looking at flow measurements for 2014 there are many periods of elevated flow throughout the recreational season. This means that there are many times during the days following peak flows that are likely to see recreational users in the creek. The current warning sign in Castlewood State Park, which is well located in the main swimming area, provides a general warning about the potential for bacteria in the creek. The sign does not go on to explain when bacteria levels are the highest or give a rating of the current condition. In order to provide the public with more informed precautionary information it would be a good idea to amend the existing signage to include a warning about the correlation between elevated flows and bacteria levels. This could also be an opportunity to present information about the watershed plan and possibly a QR code link to the current flow conditions from the USGS gauging station.

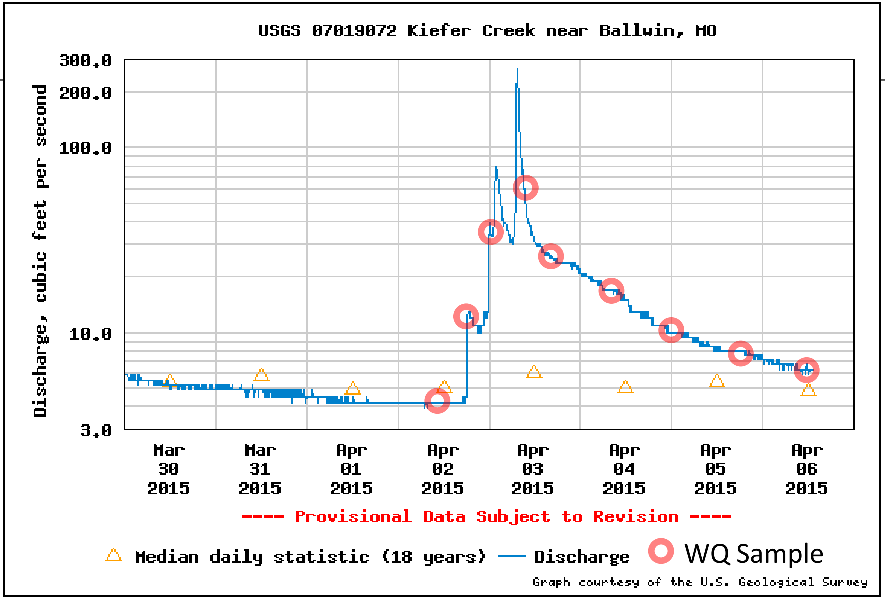
Monitoring Strategy

In addition to the scheduled monitoring by MSD; MDNR and the St. Louis County Health Department could undertake more targeted monitoring approaches to fully understand the correlation between rainfall, flow and bacteria concentrations. It would be immensely beneficial to collect samples sets before, during and after a rain event on an annual basis during the recreational season. Starting prior to the rain event, samples could be collected at intervals such as every 4, 6 or 12 hours or in the morning and afternoon, continuing until at least 72 hours after the peak flow conditions or when flow stabilizes around the 50th percentile flow of 2.5 cfs.

USGS SUMMARY STATISTICS

	Water Year 2014		Water Years 1996-2014	
Annual total	1,165			
Annual mean	3.19		5.55	
Highest annual mean			9.31	2010
Lowest annual mean			3.11	2001
Highest daily mean	55	3-Apr	302	9/14/08
Lowest daily mean	0.94	25-Oct	0.51	5/6/08
Annual 7-day minimum	1.01	22-Oct	0.629	8/22/03
Maximum peak flow	1,320	1-Sep	2,570	9/14/08
Maximum peak stage	7.59	1-Sep	10.48	9/14/08
Annual runoff (cfsm)	0.816		1.42	
Annual runoff (inches)	11.1		19.3	
10 percent exceeds	5.28		11	
50 percent exceeds	1.8		2.5	
90 percent exceeds	1.2		1.2	

This type of coordinated monitoring presents two significant logistical challenges. Someone will have to collect and deliver the sample to the lab, and proper quality control measures require that a sample be delivered to a laboratory for bacterial testing within 6 hours of the collection time. These difficulties may be surmounted with enrollment of watershed partners at the Wildlife Rescue Center and Castlewood State Park in the collection of samples at regular intervals. The person taking the sample will have to coordinate closely with the lab to ensure that samples are received in time. This testing protocol could achieved through a university partnership to gain access to a laboratory during non-business hours for research purposes.



In the example above proposed rain event sampling times have been overlaid on a USGS hydrograph of a rain event in Kiefer Creek

It is also very important to continue the review of water quality data in Kiefer Creek at regular intervals over the course of the implementation of best management practices and non-point source pollution reduction strategies. The results of this analysis will be used to gauge the effectiveness of the practices that have been implemented and inform the adaptation of the watershed plan.

On an annual basis, new monitoring data and trends should be compared to implementation measures and milestones in each sub-basin and in the overall watershed. MSD already assembles annual reports on the data they collect in the watershed, and they could also provide a list of parcels in the watershed that have been added to the sanitary sewers over the past year. MDNR and a watershed coalition could collect information regarding other best management practices according to the milestones for each practice. BMPs that are funded through 319 grants would require extensive reporting on implementation activities. The watershed coalition partners could keep track other implementation activities and hold a meeting on a yearly basis to review the findings, discuss implementation successes and challenges, and tweak ongoing efforts and projects. Every five years the plan should be revisited and revised based on major trends and successes.

Monitoring Strategy

In addition to the traditional water quality monitoring approach with enhanced timing, there are also advanced technologies and innovative strategies that could be employed in the watershed to help better understand the nature of the non-point source imbalances in the watershed and track progress in our efforts to restore balance.

Continuous Automated Water Quality Monitoring **–** Logistical challenges will doom any water quality monitoring strategy that is dependent upon consistent involvement of employees and/or volunteers to obtain, transport, analyze and report on water quality from grab samples. The bottom line is that human involvement is very expensive and very time-consuming. And in our Kiefer Watershed there is no entity – individual or otherwise -- involved with or located in this watershed that's going to take this open-ended job on. Continuous automated water quality sampling technology is progressing rapidly, and can meet most of the need of the Kiefer Creek Coalition. Kiefer Creek Coalition will engage University resources and possibly the USGS to develop a continuous water quality monitoring program. ***Data will be collected using a Sonde that will measure Turbidity, Optical Dissolved Oxygen, Temperature, Specific Conductance, pH and Optical Brighteners***. In addition to providing data for research, the data will populate a public-facing dashboard and will be a key strategy in engaging the user community of Kiefer and Castlewood and in mobilizing the larger voting population of the St. Louis area to encourage the more difficult and expensive strategies to address the key impairments of Bacteria and Chloride of Kiefer Creek.

SHORT TERM (2015-2020) – **Implement Continuous Automated Water Quality Monitoring Program**
MILESTONE: Sonde is purchased and installed in Kiefer Creek.
ACHIEVEMENT CRITERIA: Sonde provides continuous water quality data that is utilized by project partners to inform and adapt implementation.
LONG TERM (Post-2020) – **Continue Continuous Data Collection and Map Long Term Trends in Water Quality**
MILESTONE: 5+ years of continuous water quality data collected
ACHIEVEMENT CRITERIA: Long term data provides valuable insights into the results of implementation efforts and is used to inform subsequent adaptations of the watershed plan.

TECHNICAL ASSISTANCE: Saint Louis University, University of Missouri Science and Technology, United States Geological Survey.
FINANCIAL ASSISTANCE – Hardware estimate: $10,000, Annual Operation and Maintenance Expense: $3,000.
MONITORING – Data collected by the Sonde would be available to the public and would be analyzed and reviewed by the Kiefer Creek Watershed Group, MSD, MDNR, St. Louis County Health Department and other project partners.

Genetic Source Tracking - It is one thing to know that there is a high concentration of bacteria in Kiefer Creek, it is another to be able to break this down into sources. With genetic source tracking it is possible to identify genetic markers in bacteria which tell us what kind of animal they came from. This information could be a vital resource in determining the effectiveness of bacteria reduction and management BMPs and provide more clarity on the relative contributions of bacteria from the sources identified in this plan. This process is expensive and relies on a samples set which limits the overall accuracy in estimating the relative quantities of bacteria, however the technology will likely evolve over the next 15 years and it should be employed at the earliest possibly opportunity in the Kiefer Creek Watershed. Over time the process can be improved and used to characterize bacteria loading during different hydrologic conditions in the watershed.

SHORT TERM (2015-2020) – **Implement Genetic Source Tracking**
MILESTONE: Samples are collected and tested for genetic source testing on at least an annual basis.
ACHIEVEMENT CRITERIA: Bacterial source composition of high and low flow conditions are revealed and are used to guide implementation efforts and strategies.
LONG TERM (Post-2025) – **Enhanced Genetic Source Tracking**
MILESTONE: Samples are collected from multiple sites concurrently
ACHIEVEMENT CRITERIA: Enhanced understanding of bacteria load is used to target implementation investments and projects.

TECHNICAL ASSISTANCE: Local universities and trained watershed volunteers may be able to collect samples, universities may also have the equipment necessary to conduct this testing.

FINANCIAL ASSISTANCE – A professional service provider is more likely than a university to have a well developed, and agency approved, methodology. Professional source tracking would cost about $600 -$800 per sample, which would include quantification of dog, horse, deer, bird and human bacteria. *http://www.sourcemolecular.com/about-sourcemolecular/about-source-tracking.html*

Aerial Infrared Detection of Failing Septic Systems – As we pointed out earlier in this section, septic systems are expensive to fix and failures may go undetected. There are <260 residential septic systems in Kiefer watershed. 99% are in unincorporated St. Louis County. Estimate 90+% of fecal bacteria in Kiefer is coming from these 260 lots. St. Louis County Health Department has no authority to inspect without a specific complaint or without proof of a failing system. Saint Louis University Parks College Engineering, Aviation and Technology is interested in designing a FLIR aerial detection program, perhaps utilizing UAVs to collect wintertime aerial infrared imagery that can be used to identify failing septic systems and would also potentially reveal as yet unknown karst features in the watershed . Findings can then be provided to St. Louis County Health for their action under existing statutes.

SHORT TERM (2015-2020) - **Implement an Aerial IR Detection Program**
MILESTONE: Engage Partner, such as St. Louis University, utilize aerial IR tools to collect high resolution wintertime aerials in areas with septic systems in the Kiefer Creek Watershed.
ACHIEVEMENT CRITERIA: Determine tool viability, publish results.

MID TERM (2020-2025) - **Continue Program as Needed**
MILESTONE: Continue partnership and refine imagery collection and analysis based on feedback from infrastructure partners.
ACHIEVEMENT CRITERIA: Publish results and findings are used to inform infrastructure and remediation strategies and investments.

TECHNICAL ASSISTANCE: Partner, such as Saint Louis University
FINANCIAL ASSISTANCE: Annual Budget: $5,000 - Funding from Various Grant Programs

MONITORING - Technical Partner, such as Saint Louis University to publish results. The Kiefer Creek Watershed Group, MSD, St. Louis County and the East West Gateway Council will review results and integrate findings into strategic investments in septic system remediation.

Animal Surveillance Program – Identify populations of indicator species, possibly concentrating on amphibians, sensitive to Bacterial Impairment and/or Chloride Impairment, in Kiefer Creek. Stream dwelling amphibians can serve as important ecological indicators of habitat quality. In small headwater streams, such as Kiefer, where amphibians replace fish as the top vertebrate predators, they serve as a potential tool to assess stream health and critical impairments. In fact, several monitoring programs sponsored in other States have determined that fish indicators are ineffective in headwater streams, where flow is too low to sustain healthy populations. In these areas of low flow, amphibians may provide valuable information. Biological monitoring will detect changes in water quality and habitat, and provides an indication of overall stream health. Goal of the project is to provide data on indicator species, such as amphibians, and to help drive community participation in a social marketing behavior change campaign.
SHORT TERM (2015-2020) – **Implement Animal Surveillance Program**
MILESTONE:Engage Scientific Partner, such as Institute for Conservation Medicine, Saint Louis Zoo. Begin baseline data collection
ACHIEVEMENT CRITERIA: Baseline data is created for selected species
LONG TERM (Post-2020)
MILESTONE: Continue Scientific Project
ACHIEVEMENT CRITERIA: Publish Research Findings which are used to inform the habitat and aquatic ecosystem restoration strategy.

TECHNICAL ASSISTANCE: Scientific Partner, such as Institute for Conservation Medicine, Saint Louis Zoo
FINANCIAL ASSISTANCE: Annual Budget: $5,000 - Funding from Various Grant Program

MONITORING - Scientific Partner, such as Saint Louis Zoo to publish results. Kiefer Creek Watershed Group, TNC, MDC, MDNR, MSD and other project partners will review the findings and use them to inform adaptation of the aquatic life and habitat restoration strategies.

Implementation Schedule

BACTERIA - SEPTIC SYSTEMS

Implement a Septic System BMP outreach program to all (<260) non-sewered parcel owners in watershed.

Partners: MSD and the East West Gateway Council can provide informational materials and web content that have been developed to help homeowners manage their septic systems. The Kiefer Creek Watershed Committee will review implementation information on the execution of the strategy, the number of homeowners reached, the number of pledges taken and implementation of recommended BMPs. St. Louis County may also be able to provide support by ensuring that county inspectors and engineers are also part of the group that provides information to homeowners with septic systems, which will benefit all of the watersheds in the county that still have septic systems.

		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
SHORT-TERM	**Implement a Septic System BMP outreach program to all (<260) non-sewered parcel owners in watershed.**	x	x	x	x	x										
	Conduct outreach campaign via mailing campaign and public signage to explain the scope of problem and recognize early adopters who do what they can at this time to be part of the short-term solution.	x	x	x	x	x										
	Give the parcel owners something that they can do NOW to begin to address the problem. Be sensitive to the fact that they are private property owners, but raise awareness among the parcel owners and the general park community that the septic waste from less than 260 watershed properties is a danger to Public Health in a State Park with over 650,000 Park Visits per year.	x	x	x	x	x										
	Parcel Owners will pledge to participate in voluntary program.	x	x	x	x	x										
	Mapping watershed septic systems - Develop a robust map within CCCW showing the locations of specific properties not served by MSD. St. Louis University/Parks will also use the map to start scoping their aerial thermography initiative for detecting failing septic systems and IDDs.	x	x	x	x	x										
	Customize an existing septic module of a public outreach campaign. Module is part of an overall social marketing engagement strategy.	x	x	x	x	x										
MID-TERM	**Evaluate and Enhance existing Septic System BMP program, make sure septic system owners are apprised of new resources and technical assisntance available to them.**					x	x	x	x	x						
	Publicly recognize those septic system landowners for participating in the septic system BMP program, Connecting to existing laterals as the Sewer Main Expansion Project continues and taking advantage of cost-share programs.					x	x	x	x	x						
LONG-TERM	**Continue enhancement of Septic System BMP program for Septic systems in watershed that are not connected to the sewer mains.**										x	x	x	x	x	x
	Recognize those few septic systems that are not able to connect to Sewer Mains but that have implemented other best practices or alternative technologies to ensure protection of Kiefer Creek.										x	x	x	x	x	x
	Estimate Cost	$5000/Year				Evaluate Costs					Evaluate Costs					
	% Participation by Septic System Owners	*5*	*10*	20	30	50	70	90	100	100	100	100	100	100	100	100
	% Reduction in Septic System Load	*1*	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Implementation Schedule

Implement an inspection, pump-out and 'time of sale' inspection program based on effective policies and programs in other communities.

	Partners: St. Louis County, East West Gateway Council, MDNR, MDHSS and MSD are the primary partners that will be integral to the development and implementation of policies and provision of resources identified. Homeowners with septic systems should also have a strong voice in this process in order to ensure that the outcome provides a good balance of requirements and resources to achieve compliance. Technical Assistance: Agency partners with expertise in septic systems, public health, sewers and developing funding for infrastructure will help craft the policy framework and develop homeowner resources.	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
SHORT-TERM	**Convene discussions with partners and stakeholders to inform the recommended ordninance language and build support and buy in from all parties impacted.**	x	x													
	When a property is being prepared for sale it shall have its sewerage system inspected by a licensed inspector, the inspection shall also evaluate the potential to connect to centralized sewers and the applicable regulatory requirements. If the system is found to be failing the cost of needed upgrades, repairs, or optimally a connection to sewers will be included in the sale price of the home and completed prior to the issuance of an occupancy permit.	x	x													
	Ordinance to require that all St. Louis County citizens that have a septic system on their property are required to have their septic system pumped out and inspected by a licensed sewage handler at least once every five (5) years. Septic system owners may elect, as an alternative to this pump-out requirement, to submit documentation that the system was inspected by a certified operator or on-site soil evaluator within the last 5 years and found to be functioning properly and does not need to be pumped out. A listing of certified operators and on-site soil evaluators will be maintained by the County.	x	x													
	When there is a proposed change in use or expansion of the facility which requires a building or occupancy permit. This does not mean an inspection is required every time a building permit is needed - only when the use of the facility is changed (e.g., from residential to commercial) or when a facility is expanded (e.g., when a bedroom is added, the square footage of an office building is expanded, or seats are added to a restaurant).	x	x													
	Any change in the footprint of a building also requires an inspection to determine the location of the system to ensure that new building construction will not take place on top of any system components or on the reserve area of the system. If official records are available to determine the location of the system components, the physical inspection is waived.	x	x													
	When the property is divided or ownership of two or more properties is combined an inspection should be conducted.	x	x													
	Develop funding and financing opportunities to help homeowners easily comply with new requirements.	x	x	x	x	x										
	Provide funding for free septic system inspections in conjunction with free or discounted pump-out and time of sale inspection requirement.	x	x	X	X	X										
	Provide homeowners with the resources needed to finance system upgrades, repairs or sewer connections (see Lateral Program Funding and Partnerships and Neighborhood Improvement District).	x	x	X	X	X										
	Help homeowners buying or selling homes with septic systems implement necessary upgrades, repairs or sewer connections	x	x	X	X	X										
	Educate legislators on the issue and proposed policy changes and funding strategies, and provide them with examples of the support for these changes from members of the public and from Agency Partners.		x	X	X	X										
	Adoption of policy changes and implementation of funding strategies.				X	X										

Implementation Schedule

Implement an inspection, pump-out and 'time of sale' inspection program based on effective policies and programs in other communities (continued)

Partners: St. Louis County, East West Gateway Council, MDNR, MDHSS and MSD are the primary partners that will be integral to the development and implementation of policies and provision of resources identified. Homeowners with septic systems should also have a strong voice in this process in order to ensure that the outcome provides a good balance of requirements and resources to achieve compliance. Technical Assistance: Agency partners with expertise in septic systems, public health, sewers and developing funding for infrastructure will help craft the policy framework and develop homeowner resources.

Term	Action	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
MID-TERM	**Enforcement of new septic system requirements in conjunction with resources and support for homeowners needing to make system repairs or sewer connections.**						x	x	x	x	x					
	Septic Systems are inspected periodically and at the time of sale.						x	x	x	x	x					
	Homes with inadequate system design that can be connected to existing or expanded sewers, are connected.						x	x	x	x	x					
	Homes with inadequate system design that cannot be connected to existing or expanded sewers are evaluated for alternative solutions (composting toilet, new septic system)						x	x	x	x	x					
	Routine maintenance is performed on all remaining septic systems.						x	x	x	x	x					
	Participating and impacted homeowners are provided with sufficient resources and financial tools to expeditiously achieve compliance.						x	x	x	x	x					
LONG-TERM	**Continued Enforcement of septic system requirements in conjunction with resources and support for homeowners needing to make system repairs or upgrades. Increase in sewer connections to expanded sewer infrastructure.**											x	x	x	x	x
	The second round of inspections will have been completed fostering new connections to new sewer infrastructure.											x	x	x	x	x
	Homes with inadequate system design that can be connected to existing or expanded sewers, are connected.											x	x	x	x	x
	Homes with inadequate system design that cannot be connected to existing or expanded sewers have implemented alternative solutions to protect recreational use in Kiefer Creek.											x	x	x	x	x
	Routine maintenance is performed on all remaining septic systems.											x	x	x	x	x
	Participating and impacted homeowners are provided with sufficient resources and financial tools to expeditiously achieve compliance.											x	x	x	x	x
	Estimate Cost	$5000/Year					Evaluate Costs					Evaluate Costs				
	% Reduction in Septic System Load	0	0	0	0	0	2	6	8	10	12	15	18	21	23	25

Implementation Schedule

Enhance the St. Louis County Lateral Program to address existing septic systems and develop new funding partnerships

Partners: St. Louis County, East West Gateway Council and MSD should work together to assess the best way to use lateral program funds to reduce failing systems through connections to existing and expanded sewer lines.

Term	Action	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
SHORT-TERM	**Convene discussions with St. Louis County Lateral Program representattives to evaluate potential use of lateral program funds to support new connections to sewers in Kiefer Creek, excluding new construction.**	x	x													
	Develop partnerships with potential sources of additional funding and/or matching for the construction of new lateral connections with existing properties, excluding new construction.	x	x	x	x	x										
	Successfully propose changes to the St. Louis County Lateral Program to allow use of funding to construct new lateral connections to existing homes with septic systems, with agency and partner support.			x	x	x										
MID-TERM	**Lateral program funding is used to connect septic systems to existing sewer infrastructure.**						x	x	x	x	x					
	The 'low-hanging fruit' of septic systems that can be connected to existing sewers, are all connected to existing sewers. Funds should be used to construct the shortest (least costly) connections first.						x	x	x	x	x					
LONG-TERM	**Lateral program funding is used to connect septic systems to new and expanded sewer infrastructure.**											x	x	x	x	x
	Assuming that the sewer expansion feasibility study is conducted and sewers are successfully expanded, then the lateral program could be used to ensure that homes are connected to the new sewer lines. In the past this has not always been the case.											x	x	x	x	x
	Estimate Cost	$2500/Year				Evaluate Costs					Evaluate Costs					
	% Reduction in Septic System Load	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10

Formation of a Neighborhood Improvement District

Partners: St. Louis County and Kiefer Creek Watershed Residents should work together to develop a Neighborhood Improvement District.

Term	Action	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
SHORT-TERM	**Convene discussions with St. Louis County and watershed stakeholders to evaluate the potential for the formation of a Neighborhood Improvement District and how it could help the watershed.**	x	x													
	Develop the agreements and language necessary to form a Neighborhood Improvement District through a collaboration between watershed residents, St. Louis County and the Kiefer Creek Watershed Group.		x	x												
	Form a Neighborhood Improvement District that can secure funding to provide homeowners with low or no-interest loans to expedite implementation of sewer connections, system repairs and system upgrades.			x	x	x										
MID-TERM	**Neighborhood Improvement District secures funding to provide homeowners to expedite implementation of sewer connections, system repairs and system upgrades.**						x	x	x	x	x					
	Neighborhood Improvement District disburses funding to provide homeowners to expedite implementation of sewer connections, system repairs and system upgrades.						x	x	x	x	x					
LONG-TERM	**Neighborhood Improvement District disburses funding to provide homeowners to expedite implementation of sewer connections, system repairs and system upgrades.**											x	x	x	x	x
	Neighborhood Improvement District Funding is utilized to assist homeowners in resolving septic system failures.											x	x	x	x	x
	Estimate Cost	$1200/Year				Evaluate Costs					Evaluate Costs					
	% Reduction in Septic System Load	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10

Implementation Schedule

Sewer Infrastructure Expansion

Partners: East West Gateway Council and MSD will be the lead partners on this effort with engagement from St. Louis County, Kiefer Creek Watershed Group and watershed residents.

Term	Action	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
SHORT-TERM	**Bring together partners necessary to develop funding and provide technical expertise for the development of a sewer expansion feasibility study in the Kiefer Creek Watershed.**	x	x													
SHORT-TERM	**Develop and submit proposal for funding to move forward with the sewer expansion feasibility study under section 604b of the Clean Water Act.**		x	x												
SHORT-TERM	**Conduct a Kiefer Watershed Sewer Expansion Feasibility Study.**			x	x	x										
MID-TERM	**Develop and submit a proposal for funding to move forward with the sewer expansion recommendations from the feasibility study.**						x	x								
MID-TERM	**Begin implementing the recommendations of Sewer Expansion Feasibility Study.**							x	x	x	x	x	x	x		
MID-TERM	**Track lateral connections made to expanded sewer lines.**							x	x	x	x					
LONG-TERM	**Complete the recommendations of the Sewer Expansion Feasibility Study.**														x	x
LONG-TERM	**Track lateral connections made to expanded sewer lines.**											x	x	x	x	x
	Estimate Cost	$2500/Year				Evaluate Costs					Evaluate Costs					
	% Participation by Septic System Owners															
	% Reduction in Septic System Load	*0*	*0*	0	0	0	0	1	2	4	6	9	12	15	18	20

Direct use of 319 funds to eliminate failing septic systems

Partners: Support of this approach by the Missouri Department of Natural Resources will be critical to its success. MSD and East West Gateway Council will be able to help develop priorities and sensible financial tools to expedite bacteria load reductions from failing septic systems. The Kiefer Creek Watershed Group can assist in pulling together the support and engagement of watershed residents in this process.

Term	Action	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
SHORT-TERM	**Evaluate the potential to use 319 funding to fix broken septic systems, install new systems or system components, construct lateral connections to sewer lines or install an alternate technology.**	x	x													
SHORT-TERM	**Review existing information and collect additional information from septic system inspections to inform cost estimates and prioritization of investments.**	x	x	x												
SHORT-TERM	**Identify and engage with potential sources of matching, prepare 319 proposal requesting funding to make priority investments.**		x	x	x	x										
MID-TERM	**$50,000 - $100,000 in 319 funds, and the necessary matching, are secured to be utilized to address the priority septic system issues in the watershed.**															
MID-TERM	**Utilize 319 grant funds in conjunction with other funding sources to implement priority lateral connections, septic system repairs and replacement or install alternate technologies.**															
LONG-TERM	**Identify measurable outcomes from first 319 proposal, engage with sources of matching, prepare new 319 proposal informed by prior grant and requesting next round of funding to make priority investments.**															
LONG-TERM	**$100,000 - $200,000 in 319 funds, and the necessary matching, are secured to be utilized to address the priority septic system issues in the watershed.**															
LONG-TERM	**Utilize 319 grant funds in conjunction with other funding sources to implement priority lateral connections, septic system repairs and replacement or install alternate technologies.**															
	Estimate Cost	$5000/Year				Evaluate Costs					Evaluate Costs					
	% Participation by Septic System Owners															
	% Reduction in Septic System Load	0	0	0	0	0	2	4	6	8	10	12	14	16	18	20

Implementation Schedule

Implement composting toilets as an alternative technology to septic systems where site conditions and sewer access are inadequte.

	Partners: : MSD, East West Gateway Council and the Kiefer Creek Watershed Group can assist in this approach by identifying cases where there is no possible sewer connection and site conditions are prohibitive of a septic systems or the resident wishes to employ this technology because of its low cost. With multiple residents on-board, it may be possible to partner with a manufacturer and installer to get a group discount. St. Louis County can also help with the acquisition of the necessary permits and inspections needed to implement a composting toilet that complies with the county plumbing code.	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
SHORT-TERM	**Evaluate the potential use of composting toilets in place of septic systems by identifying situations where there are not adequate site conditions for a septic system and there is no access to an existing or proposed sewer line.**	x	x	x	x	x										
	Provide composting toilet information to homeowners with septic systems with a focus on those that have failing systems, and are unable to connect to centralized sewers.		x	x	x	x										
	Include composting toilets as a practice that can be supported by funding sources such as 319 and the Neighborhood Improvement District.		x	x	x	x										
MID-TERM	**Composting toilets are implemented in situations where no other solution is available or the homeowners are willing to maintain the system in order to save on long term costs.**						x	x	x	x	x					
	Support for implementation is provided through expedited inspections, permitting and technical assistance from project partners, as well as funding from 319.						x	x	x	x	x					
LONG-TERM	**Support for implementation is provided through expedited inspections, permitting and technical assistance from project partners, as well as funding from 319 and the Neighborhood Improvement District.**											x	x	x	x	x
	Composting toilets are fully implemented in all appropriate situations in the watershed.											x	x	x	x	x
	Estimate Cost	$5000/Year				Evaluate Costs					Evaluate Costs					
	% Reduction in Septic System Load	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10

References

Local/Meramec Natural Resource Documents

- Miller, Debra and Michael Coulson. Lower Meramec Greenway Study – Water Quality Considerations. St. Louis, Missouri, East-West Gateway Coordinating Council, November, 1980.
- Robert E. Criss and Elizabeth A. Hasenmueller,"Water Quality Report for Small Streams of the St. Louis Area" (report submitted in comment to the Missouri Department of Natural Resources regarding the 2010 303(d) List, 2010), 1-6.
- Sugarman, Jerry M. Meramec Heritage Riverway Plan. Sullivan, Missouri: Meramec Heritage Riverway Association, July 1977.
- The Lower Meramec Valley The Open Space Council and You….St. Louis, Missouri: Open Space Council, 1976.
- The Meramec River Recreation Association Short Range Plan 1983 – 1985. St. Louis, Missouri: Meramec River Recreation Association, 1983
- United States. Department of the Interior, and the State of Missouri Department of Natural Resources. The Meramec Concept A progress Report. Washington: GPO, November 1975.
- Missouri Coalition for the Environment,"Petition to the United States Environmental Protection Agency for Rulemaking to Protect Missouri Waters Under the Clean Water Act" petition, 2012, 30-31
- Donald H. Wilkison and Jerri V. Davis, U.S. Department of the interior, U.S. Geological Survey, *Occurrence and Sources of Escherichia coli in Metropolitan St. Louis Streams, October 2004 through September 2007*, Scientific Investigations Report 2010-5150 (Reston, VA: U.S. Geological Survey, 2010), 28, Figure 12.
- Kammer, William R. The Meramec River: Then and Now 1st Edition. St. Clair, Missouri: Riverine Publishing Co, 1996
- Missouri Department of Natural Resources, Water Protection Program, *2010 EPA Approved 303(d) List,* Jefferson City, Missouri: State of Missouri, 2011, 2.
- Constructed Sewer Overflows Map (Metropolitan St. Louis Sewer District: 2012)
- http://www.stlmsd.com/sites/default/files/education/448847.PDF
- Geroge Veni et al, "Living With Karst: A Fragile Foundation," American Geociences Institute, Environmental Awareness Series, Vol. 4. 2001, 30-33.

Horse, Pet & Wildlife Waste

- U.S. Department of Agriculture, Natural Resource Conservation Service, *New Jersey Pasture Management Guide for Horse Owners,* (Columbia, MO: 2011), 16-17.
- Scott R. Loss, Tom Will and Peter P. Marra,"The impact of free-ranging domestic cats on wildlife of the United States," *Nature Communications 4:1396* (2013) DOI: 10.1038/ncomms2380.
- American Veterinary Medical Association, *U.S. Pet Ownership Statistics: 2012 U.S. Pet Ownership & Demographics Sourcebook*, *Pet Calculator*, 2015, <https://www.avma.org/KB/Resources/Statistics/Pages/Market-research-statistics-USpet-ownership.aspx>

Septic Systems

- U.S. Environmental Protection Agency, Office of Water, Office of Research and Development, Onsite Wastewater
- Treatment Systems Manual (2002), 1-7, Table 1-3.
- Douglas L. Moyer and Kenneth E. Hyer, U.S. Department of the Interior, U.S. Geological Survey, *Use of the*
- *Hydrological Simulation Program–FORTRAN and Bacterial Source Tracking for Development of the Fecal Coliform*
- *Total Maximum Daily Load (TMDL) for Blacks Run, Rockingham County, Virginia*, Water-Resources Investigations
- Report 03-4161 (Richmond, VA: 2003), 26-34.
- U.S. Environmental Protection Agency, Office of Water, Office of Research and Development, Onsite Wastewater
- Treatment Systems Manual (EPA/625/R-00/008, Washington, DC: GPO, 2002), 1-7, Table 1-3.

References

Data

United States Geological Survey, National Water Information System: Web Interface, *Water Quality Samples for Missouri: USGS 0719072 Kiefer Creek near Ballwin, MO, 1996 to 2004,* <http://nwis.waterdata.usgs.gov/mo/nwis/qwdata/?site_no=07019072&agency_cd=USGS>

St. Louis County Missouri, GIS Service Center, *Saint Louis County Parcel Dataset,* [DVD-Shapefile] St. Louis County Government, 2014.

Missouri Department of Natural Resources, Department of Environmental Quality, Water Protection Program, *MO 2012 National Pollutant Discharge Elimination Systems (NPDES) Outfalls*, [FTP-Shapefile], 2012, <ftp://msdis.missouri.edu/pub/Environment_Conservation/MO_2012_National_Pollutant_Discharge_Elimination_System_Outfalls_shp.zip>

U.S. Department of Commerce, U.S. Census Bureau, *MO 2010 TIGER Census Tracts*, [FTP-Shapefile], 2010, <ftp://msdis.missouri.edu/pub/Administrative_Political_Boundaries/MO_2010_TIGER_Census_Tracts_shp.zip>

Media

Stephen Deere, “Castlewood creek popular despite E. coli levels,” *St. Louis Post-Dispatch*, July 27, 2010, St. Louis Post-Dispatch on the Web, accessed January 8, 2015.